OIL SHALE TRACT C-b

DETAILED DEVELOPMENT PLAN AND RELATED MATERIALS

VOLUME 2 OF 2

- SUMMARY OF FIRST YEAR
- ENVIRONMENTAL BASELINE PROGRAMS AND ENVIRONMENTAL SETTING

C-b SHALE OIL PROJECT

ASHLAND OIL, INC.
SHELL OIL CO., OPERATOR

Oil Shale Tract C-b

DETAILED DEVELOPMENT PLAN

AND

RELATED MATERIALS

VOLUME II

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VII. INTRODUCTION AND SUMMARY

The Lessee has conducted extensive baseline studies over the past year or more to determine the existing condition of the environment of Tract C-b. The detailed data from those studies have been filed by the Lessee with the AOSS in Quarterly Data Reports. The data collected for the first year of study (April 1974 through October 1975), briefly described in this section, are the basis for the detailed interpretation and analysis contained in further sections of this volume.

The baseline studies commenced at various times in 1974 following approval by the AOSS. The starting dates of special field studies were as follows:

Baseline Program	Commencement Of Field Studies
Surface Water Studies	April 23, 1974
Flora Studies	Mid-August, 1974
Fauna Studies	Mid-August, 1974
Aquatic Ecology Studies	Mid-August, 1974
Soil Productivity Studies	Mid-August, 1974
Air Quality Studies	September 1, 1974
Soils and Geology Studies	Late October, 1974
Ground Water Studies	July 1, 1974

In this document, environment refers to the entire complex of chemical, physical and biological factors and interactions that influence an organism and its behavioral patterns. Physical and chemical factors of the environment include such features as the air, water, land, geologic formations, climate, temperature ranges and solar radiation. The biological components, including the plants and animals themselves, are equally important, as are the habitats individual species occupy.

Specific physical habitats, and all of the organisms which interact within them, are part of larger organizational units called ecosystems. These units may be as large as the Rocky Mountain Range or as small as a stand of Douglas-fir. An ecosystem is a basic fundamental unit that includes both biotic and abiotic environments, each influencing the properties of the other. Both are necessary for the maintenance of life.

Setting. The Piceance Creek basin, between the Colorado River on the south and the White River on the north, is dominated by a large central plateau which represents more than 75% of the basin's land surface. Precipitous cliffs form the southern boundary of the plateau. The upland surface of the plateau slopes gently away from the cliffs toward the interior of the basin. The elevation of the basin ranges from 5000 to 9000 feet.

The Tract is located in the southeastern portion of the Piceance Creek basin. In the vicinity of the Tract, the main topographic features are a series of northeast-trending linear ridges and valleys that are typical of the plateau surface. Two of the valleys, Willow Creek and Stewart Gulch, contain perennial streams which flow into Piceance Creek just north of the Tract. Piceance Creek itself flows west and north to the White River. The elevation of the Tract averages about 6800 feet.

Geology. Geologically, the Tract is situated on the north-dipping flank of the Hunter Creek syncline. The structural dip is approximately one and a half degrees, and no significant faults have been identified.

The Mahogany zone is the geologic unit of principal interest beneath the Tract because it contains the richest oil shale section in this part of the basin. A relatively rich oil shale unit within the Mahogany zone has been delineated as a possible mine zone. It has an average thickness of 77 feet and is estimated to contain 940,000,000 barrels of oil in place. The oil shale below the Mahogany zone is generally lean compared to the Mahogany zone, and current plans do not include commercial development of these lower zones. The nahcolite and dawsonite under the Tract occur in relatively low concentrations in lean oil shale zones and have no commercial potential at this time.

Hydrology. The largest stream near the Tract is Piceance Creek, with an average annual flow of 14,500 acre-feet. Approximately 80% of the flow is believed to be from ground-water discharge. At the mouth of Piceance Creek, the total dissolved solids (TDS) average 2000 milligrams per liter (mg/l). The main constituents are magnesium, sodium, bicarbonate and sulfate.

Some tributary streams to Piceance Creek have higher concentrations of TDS than the main stream. From a point above the Tract to a point below the Tract, the concentration of TDS in Piceance Creek increases by about 30%. During periods of storm runoff or snowmelt, the addition of higher-quality water lowers the TDS concentration. To date, the primary utilization of surface water is for irrigation. During the irrigation season, the TDS increases due to leaching of the soil on the irrigated lands and the reentry of runoff into the streams.

The two principal aquifer (underground water) systems in the Piceance Creek basin are: 1) the upper aquifer, which consists of fractured oil shale above the Mahogany zone, the Uinta formation and the alluvial

deposits along valley bottoms; and 2) the lower aquifer, which is the fractured oil shale below the Mahogany zone. The porosity and permeability of the lower aquifer has been increased by dissolved nahcolite, and the interval where this has occurred is commonly referred to as the leached zone.

A thin, organic-rich layer within the Mahogany zone appears to separate the upper and lower aquifers both chemically and hydraulically. The vertical flow of water within the upper and lower aquifers is further restricted by several thin zones of rich oil shale which have very low permeabilities.

Hydrologic production tests on the Tract indicate that the potential water flow from the water-bearing intervals in the Uinta formation and the underlying Parachute Creek member of the Green River formation is highly variable. Generally, it is low, ranging from about 120 to 350 gallons per minute (GPM). The average yield of the upper aquifer during an extended pump test was 373 GPM. The yield of the lower aquifer was 120 GPM. Horizontal permeabilities range from zero to 300 millidarcies. Vertical communication between the various aquifer layers is restricted, and therefore the vertical flow between layers is limited and predictable to a certain extent. Within limits, this allows controlled dewatering of certain aquifers independent of others. Preliminary analyses indicate that the permeability distribution in individual layers is anisotropic. Potentiometric maps of the upper and lower aquifer suggest that flow in both systems is from south to north across the Tract. In all wells on the Tract, the head in the upper aquifer is always higher than the head in the lower aquifer.

The TDS of the upper and lower aquifers on the Tract ranges up to about 2200 mg/l. In general, the lower aquifer is more saline than the upper aquifer, and the water in the Parachute Creek member above the Mahogany zone is less saline than the water of the overlaying Uinta formation. Within each major aquifer, the concentration of TDS fluctuates over a range of several hundred mg/l. Water from the upper aquifer is generally a mixed sodium-sulfate/sodium-bicarbonate type. The lower aquifer water is a sodium-bicarbonate type.

Air Quality. The Piceance Creek basin is commonly referred to as a pristine area in the sense that it is free from atmospheric pollution. Air quality data indicate that this is not a completely accurate picture of the basin's atmosphere in the immediate vicinity of the Tract.

The ambient air is monitored on the Tract plateau and in the Piceance Creek valley and analyzed for several different gaseous species and particulates on a daily basis. Monthly averages of these data have shown ambient air concentrations for most of these gases to be near the background levels, which occur naturally. However, on occasion, these data have indicated ambient air concentrations substantially above the usual background concentrations. A reasonable explanation is that other manmade or natural sources in the vicinity of the Tract sometimes cause increased concentrations.

Likewise, ambient air concentrations for particulates, though typically low, can vary over a wide range. These variations are primarily caused by fugitive dust stirred up by the frequent winds or, to a lesser extent, by the human activity and automobile traffic.

Meteorology. Precipitation, relative humidity, vertical temperature profiles, surface wind patterns and wind speed are very dependent on the local topography. During the period from November 1974 through July 1975, a maximum hourly temperature of 90°F was recorded (in July 1975) both on the Tract plateau and in the Piceance Creek valley, which is 600 feet lower in elevation. The minimum temperatures for the plateau and the valley were -29°F and -51°F, respectively, occurring in January 1975. Substantial differences in the minimum temperatures between the plateau and valley are common, particularly in the colder fall and winter months. This phenomenon is caused by the topography, which encourages downslope drainage of the colder air into the lower-lying valleys. This also results in more stable atmospheric conditions in the valleys and tends to restrict vertical air movement. Thus the colder air tends to collect in the valleys and even further cooling takes place.

The higher plateaus in the area generally receive more precipitation than the valleys and lower-lying areas. To date, the maximum monthly precipitation on the Tract was 1.2 inches in May 1975; during July 1975, 0.85 inches fell in the Piceance Creek valley. Relative humidities ranged from a high of 100% to a low of 8%. The average is 62%, while diurnal variations of 80% are common, particularly in the Piceance Creek valley. In the valley, irrigation activities and large diurnal temperature variations cause large relative humidity variations.

The surface wind patterns are greatly influenced by the irregular terrain, which gives rise to both mechanically induced and thermally induced turbulence. Hourly average wind speeds range from 3 to 10 MPH and are generally higher on the Tract plateau. Gusts to 79 MPH have been recorded at the meteorological tower on the Tract plateau during the spring, when the strongest winds occur. Wind speed and direction on the Tract plateau are typically influenced by both the synoptic-scale wind and the frictional effects of the land surface and temperature gradients. Wind direction on the Tract plateau is predominantly from the south and southwest as determined by the synoptic winds. The valley winds are typically channeled up the valleys in a southeasterly direction or down the valleys in a northwesterly direction.

Strong outgoing terrestrial radiation during the night can cause rapid cooling of the surface air, resulting in inversions which impede the vertical flow of air. Measurements of the variation in temperature at increasing altitudes (the lapse rate) can help determine the presence and intensity of an inversion. These measurements, to date, show that the fall and winter months tend toward more stable conditions, particularly during the daylight hours. In contrast, the spring and summer

months generally show less stable conditions, which tend to destabilize further during the daylight hours as the thermal turbulence increases with the heating of surface air.

Flora. Approximately 175 species of vascular plants in the Tract area have been identified to date. These species are characteristic of the Rocky Mountain and Great Basin floristic regions. Composites, grasses, mustards and legumes are the most commonly encountered plants. No endangered or threatened plant species have been observed within the study area.

Vegetation community types include pinyon-juniper woodlands, chained pinyon-juniper rangelands, upland and valley sagebrush communities, Douglas-fir forests, mixed mountain shrublands, bunchgrass communities, Great Basin wild rye communities, rabbitbrush communities, greasewood communities, marshes, riparian communities, agricultural fields, annual wild communities, aspen woodlands and mountain grasslands.

The alteration of approximately 45% of the Tract surface area by chaining done by the BLM in 1966 has produced a rangeland characterized by many fallen trees and by a shrubland vegetation type. Because of this, herbs and shrubs on the Tract tend to be more abundant than in the neighboring pinyon-juniper woodlands. Dominant species include big sagebrush, bitterbrush, snowberry, mountain mahogany and serviceberry.

The pinyon-juniper woodlands are the most widespread in the Tract study area. Dominant species include pinyon pine and Utah juniper. Shrub and herb layers tend to be sparse. Big sagebrush, with heights over six feet, occur mostly on ridges and in clearings within the pinyon-juniper woodlands, in upland sagebrush communities, and in the bottoms of the smaller gulches and valleys. The herb layer in the upland sagebrush communities is quite diverse. It is characterized by numerous species, in contrast to the valley sagebrush communities where the herb layer is sparse and characterized by few species.

The mixed mountain shrublands form a nearly continuous layer on north-facing slopes. The herb layer in this community includes numerous species which do not occur elsewhere within the study area.

The agricultural fields in the Tract vicinity are located along Piceance Creek. Irrigated meadows are used for hay production in the summer and cattle grazing in the winter. During the fall and spring, these meadows are used by the mule deer population as feeding areas.

In the past, industrial and ranching activities on the Tract have produced conditions which allowed the development of widely distributed annual weed communities such as cheatgrass, tumble mustard, white pigweed, goosefoot and Russian thistle. Also, agricultural activities have, to a

limited extent, resulted in the growth of rabbitbrush communities on the flood plains of major drainages, where the community had been primarily valley sagebrush.

In addition to the vegetation types which occur within the Tract study area, there are three other major plant communities along the off-tract utility and pipeline corridors. Aspen woodlands occur at the highest elevations along the corridor route and are restricted to north-facing slopes. The herb layer in the higher elevations is well developed and includes many species characteristic of higher-elevation plant communities. Mountain grasslands occur on windswept hilltops and ridges at the upper end of the corridor route, and few shrubs occur in this community type.

Fauna. The Tract supports three distinct animal groups. The first group includes the small mammal populations and those bird species which are present in the area for their entire life cycle. The second group primarily consists of mule deer, migratory birds, wintering birds, breeding birds and cattle, all of which make use of the area during specific periods of each year. The third group includes medium-sized mammals and predators, which utilize the Tract area as part of their broad ranges.

Some animals occur selectively on the Tract, in restricted habitat types. For example, voles are found primarily in meadow habitats; and the red-eyed vireo has been seen only in the limited cottonwood habitat of Cottonwood Gulch. Other species such as deer mice are found almost universally in all habitat types. A greater species diversity of rodents is found in the chained pinyon-juniper type than in the unchained type, presumably as a result of the increased habitat provided by the uprooted trees and the increased understory growth.

During the period when mule deer utilize the Tract area, they seem to make use of all available habitats. Greatest use is made of the chained pinyon-juniper and plateau sagebrush vegetation types during most of the winter, and the least use of the valley sagebrush. Hay meadows along Piceance and Willow Creeks are used heavily in early fall and spring. As the winter progresses, the south-facing slopes become increasingly important as crusted snow builds up and makes access to food difficult. At these times, south-facing slopes are free of snow and are heavily used by the mule deer.

The Multi-purpose Spur Corridor south of the Tract is located at a higher elevation than the Tract itself. While no big game species other than mule deer have been found on the Tract, a few elk are found in the vicinity of the corridor. Winter and summer deer ranges appear to overlap in the corridor area with approximately equal usage of adjacent ridges.

The small and medium-sized mammals which occur on the Tract and in the corridor areas serve as prey for predatory birds and carnivorous

mammals such as the coyote. Important prey species include the voles, the cottontail and (as carrion) mule deer. Coyotes are relatively abundant in the Tract and in the corridor area, as evidenced by the results of standardized census techniques used throughout Colorado and the West. Bobcats inhabit cliff areas on the Tract and in the corridor area.

The Tract and corridor are located in nesting territory for mourning doves, and the corridor also includes areas of possible sage grouse nesting sites. No other game birds are known to inhabit the area. Raptor nests are found on the cliffs. Identified nesting raptor species include red-tailed hawks, great-horned owls and common ravens. Golden eagles are also seen in the area. Bald eagles are other uncommon winter visitors.

No rare or endangered species has been identified on either the Tract or in the corridor. A threatened species, the prairie falcon, has been sighted several times in the vicinity of the Piceance Creek road, but not on the Tract.

Aquatics. Aquatic habitats in the area of the Tract and corridor route are sparse. Most streambeds in this area contain intermittent streams, which are dry most of the year. The few existing ponds are spring-fed, existing primarily as the result of manmade dams. Some species of game fish (brook trout, a few rainbow trout and a few brown trout) are found in the creeks. Spawning occurs in Piceance Creek, in the vicinity of lower Stewart Lake, and in the lowermost reaches of Willow Creek. The most abundant fish species are nongame species such as speckled dace and mountain suckers. Water quality fluctuates in the creeks throughout the year, and is generally correlated with the amount of stream flow and with the presence or absence of cattle in the immediate area.

Soils. Seven soil series have been identified and mapped on the Tract and the surrounding one-mile area. These include Redcreek-Rentsac complex, Rentsac Channery, Piceance Loam, Forelle Loam, Glendive Loam, Hanley Loam and Hagga Loam. Analyses of the physical and chemical properties of each of these have indicated that the soils on the Tract are of light or medium texture and fall in the four categories: sandy loam; sandy clay loam; clay loam; and silty clay loam. The percent organic matter is generally moderate but the lime concentration is markedly high in all soils. As might be expected, the soils have a high pH, typically above 7.9. Some pH values are near 9.0. Nitrate values are high in all the soils, while potassium and phosphorous levels are low in all soils but the Glendive and Hanly Loams. Zinc is deficient in all the soils studied. Electrical conductivities (salts) are low to moderate except in the Glendive and Hanly Loams, where they are excessive and possibly deleterious to vegetation.

The preliminary analyses and comparisons of soil and vegetation data do not show any direct correlation between soil properties and vegetation characteristics. This does not imply a lack of correlation, but it does indicate that further investigations would be necessary in order to establish important interactions.

The soil productivity analyses conducted on soil samples from the four major vegetation types on the Tract (pinyon-juniper woodland, chained pinyon-juniper rangelands, bottomland sagebrush and upland sagebrush) have indicated that nutrient concentrations (except nitrate) are secondary to microflora activity, particularly nitrifying bacteria in supporting vegetation These analyses have shown that the Rentsac-Redcreek complex has the highest productivity of the soils occurring on the Tract. The Rentsac Channery is the lowest in productivity. Glendive Loam and Forelle Loam are intermediate in productivity. No data are available for Piceance Loam, Hanly Loam or Hagga Loam.

Scenics. Visually, the Tract and corridor areas are typical of the Piceance Creek basin, except that a large part of the Tract area has been chained. The region is quite uniform, being characterized by low rolling landforms with small stream valleys. When compared to nearby areas such as the Book Cliffs, the Roan Cliffs, the Colorado River valley and the Grand Hogback, the Piceance Creek basin is less spectacular and possesses a lesser amount of visual variety than these surrounding areas. Within the context of the basin, the Tract has few features which could be considered as visually distinctive. Much of its area is of minimal visual quality due to the chaining of the vegetation. It also should be noted that very little of the Tract and none of the corridor route is visible from any major travel route or user areas. As a result, they are not part of the scenic experience of most of the users of the area.

Archaeology. The original inhabitants of the Piceance Creek basin were nomadic hunting people who belonged either to the Ute or Pre-Ute tribes. Since the area is not suited for agriculture unless the fields are irrigated, it is not considered surprising that no village sites have been discovered in the Tract area. The area was most likely used by early peoples as a hunting area, though only a few surface artifacts have been found.

Archaeological and historical findings on the Tract and the corridor have been sparse. Studies have revealed three prehistoric sites within the Tract, one prehistoric site off-tract, one prehistoric site in the proposed corridor route and one historic site off-tract. A few isolated, scattered artifacts have been found. The prehistoric sites consisted for the most part of a few flakes, primitive tools and projectile points. The historic site includes a log cabin and a dugout.

VIII. GEOLOGY AND RESOURCES

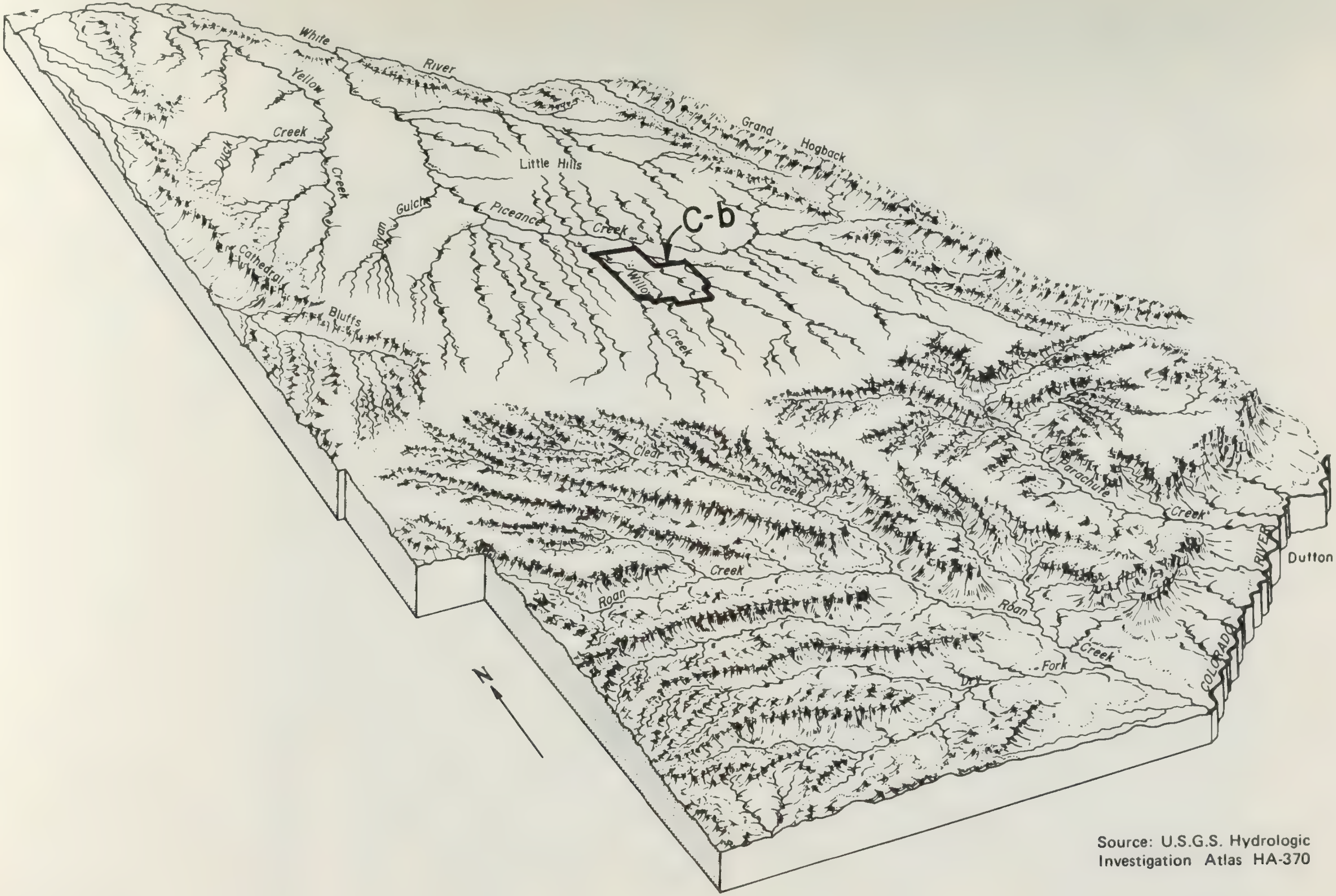
A.. Physiography

1. Regional Setting

The Piceance Creek basin is part of the high Colorado Plateau Physiographic Province. The regional terrain of the basin between the Colorado and White Rivers features a large central plateau area that occupies more than 75% of the land surface (Figure VIII-1). This plateau, which contains the richer oil shale deposits, has an average elevation of more than 7000 feet and rises from 1000 to 4000 feet above the surrounding low lands. Elevation of the basin ranges from about 5000 feet along the Colorado and White Rivers to more than 9000 feet at the highest point located northwest of Rifle. The southern and highest part of the plateau has been deeply and intricately dissected by tributaries of the Colorado River and terminates in an irregular line of precipitous cliffs. Elsewhere, the outward-facing escarpment is more regular and less steep. The upland surface of the plateau slopes gently away from the cliffs toward the interior of the basin. In this area behind the cliffs, the topography is less rugged and the terrain generally consists of a series of parallel or subparallel ridges and valleys. Local relief between ridge crest and valley floor is as much as 500 feet.

2. Tract C-b

Tract C-b is located in the southeastern portion of the Piceance Creek drainage system (Figure VIII-1). The topography of the Tract is characterized by a series of northeast trending linear ridges and valleys (Figure VIII-2). The ridges are relatively wide and convex, or flat-topped in transverse cross-sections. In general, the divide areas rise sharply some 200-250 feet above the valley floors and then slope more gently 100 to 150 feet to the ridge crests. In longitudinal cross-section, the ridges slope uniformly northward at a rate of about 120 feet per mile. The main valleys, such as East Fork Stewart Gulch, Middle Fork Stewart Gulch, Scandard Gulch, Little Scandard Gulch and Willow Creek, are relatively narrow, flat-bottomed and steep-sided. Smaller drainages such as Sorghum Gulch and Cottonwood Gulch have "V"-shaped transverse cross-sections. Both the major and minor valley walls are asymmetric. Westward facing slopes are steeper and more heavily gullied than eastward facing slopes. The main valleys have northward gradients of 80-120 feet per mile across the Tract. Minor drainages are much steeper with gradients of 200-300 feet per mile. Within the Tract area, elevations range from approximately 7000 feet at the crest of the ridges at the south end of the Tract to approximately 6400 feet in the valleys at the north part of the Tract.



Source: U.S.G.S. Hydrologic
Investigation Atlas HA-370

Figure VIII–1 BLOCK DIAGRAM
PORTION OF COLORADO PLATEAU

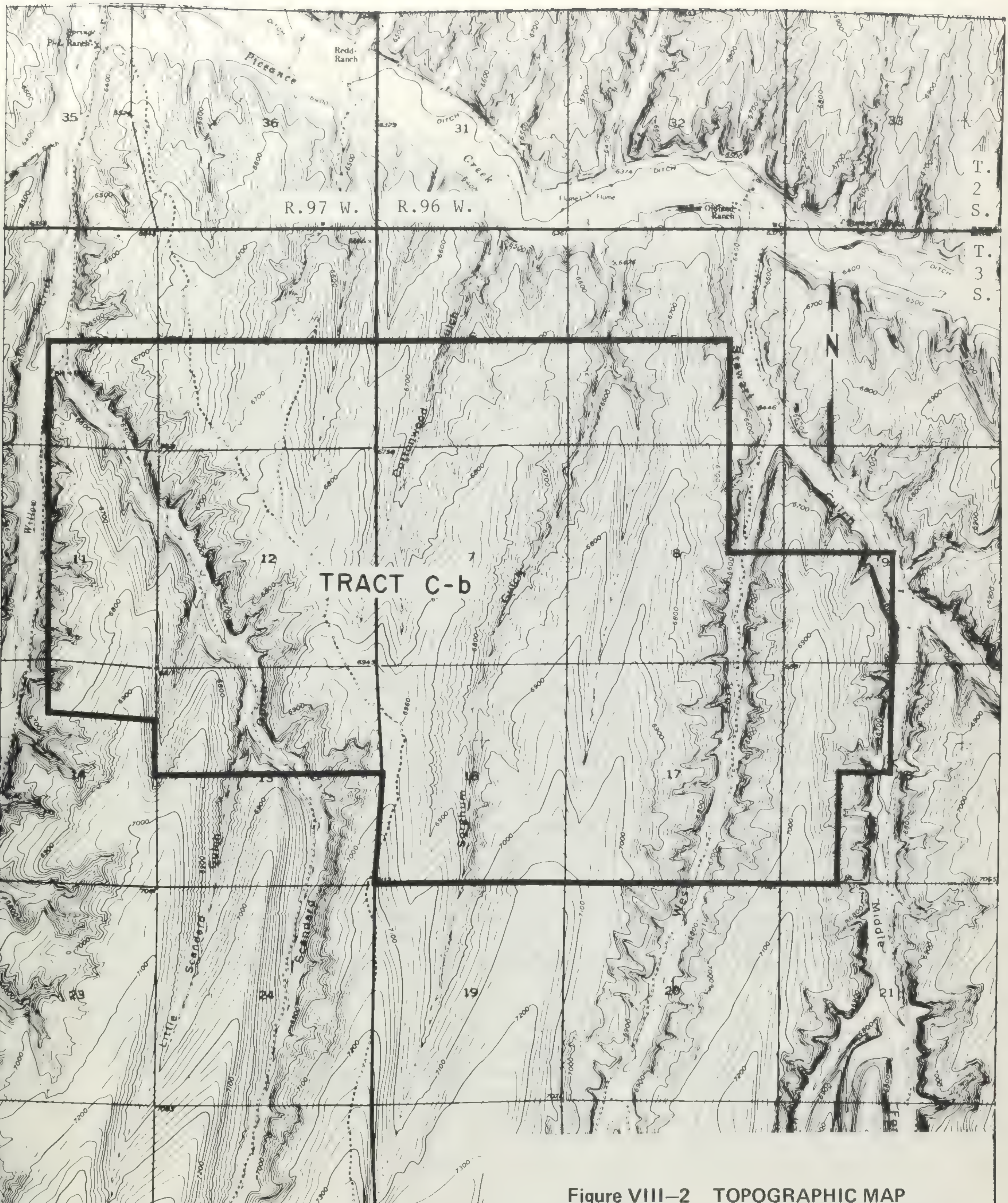


Figure VIII–2 TOPOGRAPHIC MAP OF TRACT C-b AND SURROUNDING AREA

B. Structure and Overburden

1. Regional Setting

The Piceance Creek basin between the Colorado and White Rivers is a large northwest-southeast trending structural and sedimentary basin. Regionally, the beds dip from the margins of the basin to a series of structural "lows" in the north-central part of the area. Downwarping began during late Cretaceous or early Tertiary time and continued through the period of Paleocene-Ecocene deposition in the basin. Later, the beds were folded and the entire region elevated several thousand feet above sea level. Concurrently, streams eroded much of the sediments from the highest parts of the area, exposing the oil shales in a series of cliffs around the periphery of the basin.

Although the total structural relief exceeds 3500 feet, the Piceance Creek basin is a relatively simple structural downwarp (Figure VIII-3). It is asymmetrical, with steepest dips on the northern and eastern flanks. Relatively low dips are present elsewhere in the basin and rarely exceed 5°. As indicated on Figure VIII-3, several anticlinal folds are superimposed on the smooth regional contour of the basin. These folds generally have a northwesterly or westerly trend and parallel the major structural elements in the Uinta Uplift which borders the Piceance Creek basin on the north.

Many of the anticlines are faulted. These faults, which are subparallel to the axes of the structures, are commonly paired, forming narrow grabens. Displacement of the downdropped graben blocks is as much as 200 feet.

The Piceance Creek basin has been extensively jointed or fractured. Although most of the fractures have a westerly or northwesterly trend, significant jointing occurs at approximately right angles to the major direction. Jointing appears to control the orientation of many streams in the basin.

Overburden thickness in the Piceance Creek basin is highly variable. Around the margins of the basin the rich oil shale section crops out, while in the structurally deeper parts, the potentially mineable interval that is most shallow is covered by up to 1600 feet of overburden.

2. Tract C-b

Tract C-b is located in the southeastern part of the Piceance Creek basin on the southern flank of the Hunter Creek syncline (Figure VIII-4). As shown in Figure VIII-4, the axis of this east-west trending structure is immediately north of the northern boundary of the Tract. Beneath the Tract, the beds strike approximately east-west and dip uniformly toward the north at a rate of about 150 feet per mile.

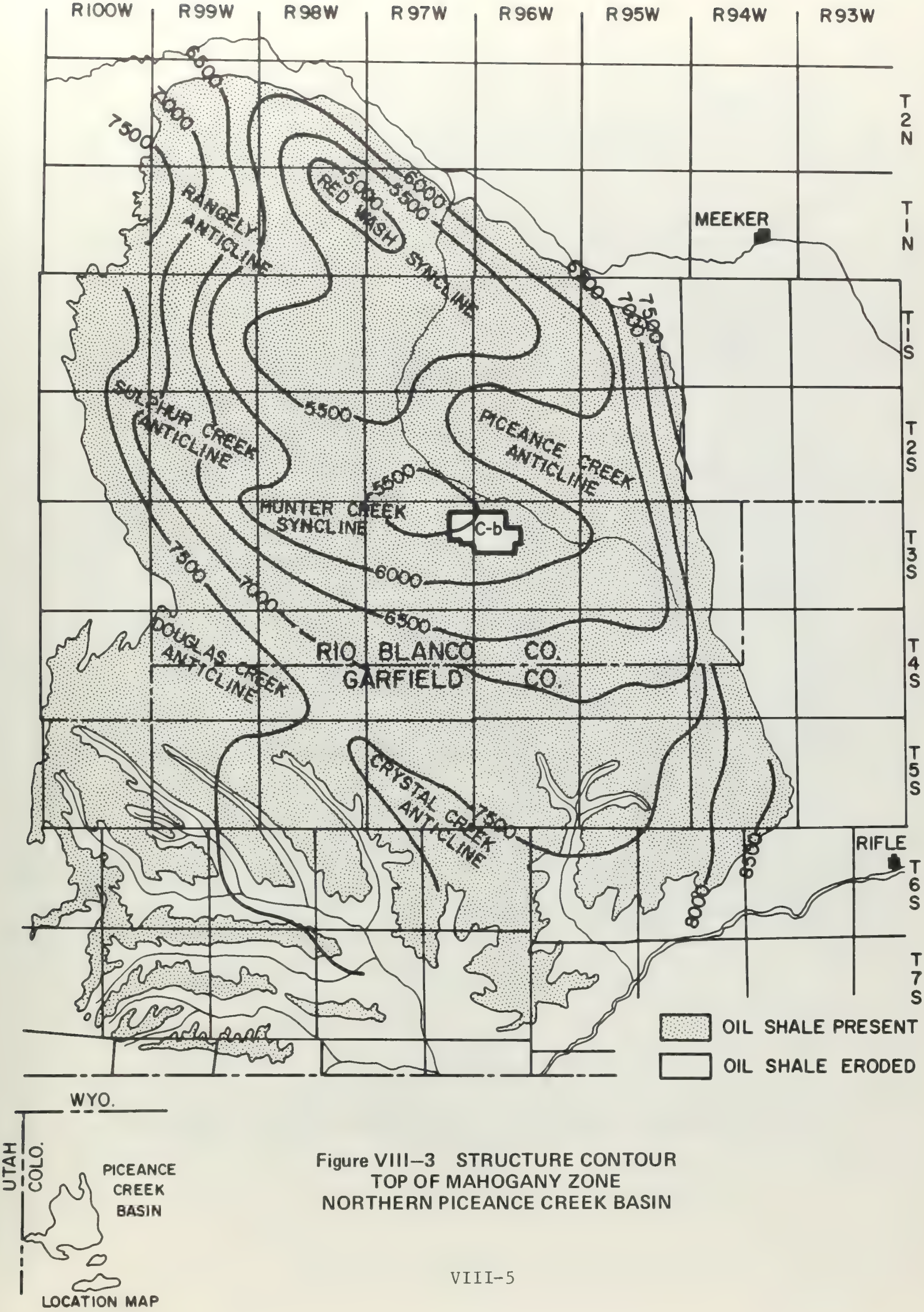


Figure VIII–3 STRUCTURE CONTOUR
TOP OF MAHOGANY ZONE
NORTHERN PICEANCE CREEK BASIN

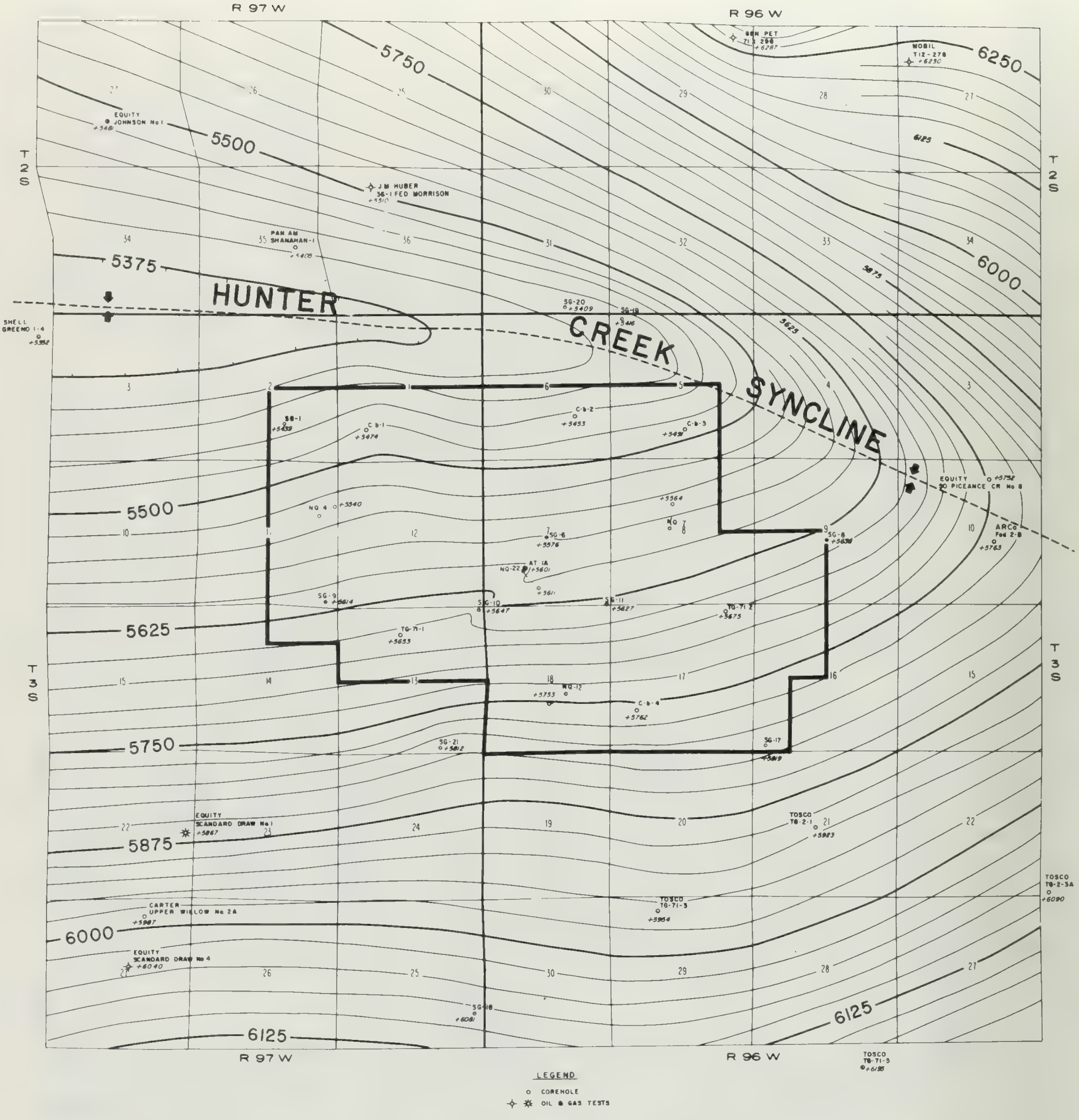


Figure VIII–4 STRUCTURE CONTOUR TOP MAHOGANY ZONE TRACT C-b

Detailed surface mapping of the Tract and surrounding area has not disclosed any significant faults. The nearest significant faults occur on the Sulphur Creek anticline about two miles northwest of the Tract. Faults also are present on the Piceance Creek anticline approximately three miles north of the Tract.

Fractures or joints are abundantly evident in the outcrops of the Uinta formation sandstones and siltstones on and around Tract C-b. Joint sets have been measured at 39 locations which are fairly evenly distributed over the Tract. These data have been analyzed to identify trends by constructing a stereographic net contour diagram (Figure VIII-5). The higher percentage areas on the diagram define two dominant joint sets. One joint set strikes N 72° W and dips vertically. The other strikes N 75° W and dips 66° to the north. Significant fracture trends in other directions are not apparent.

Fractures are also abundant in cores of the Parachute Creek oil shales. In the Mahogany zone, a preliminary analysis of oriented cores indicates that the major joint set strikes approximately N 72° W and dips 40-45° to the northeast. The strike of the joints is essentially the same as the dominant surface joint sets, but the dip of the joints is somewhat less. The difference in dip probably reflects the different mechanical properties of shale and sandstone and may also reflect some compaction of the shale after formation of the joints. Vertical joints are generally absent in the Mahogany zone. Minor joint sets strike in a number of directions, and their importance is not known.

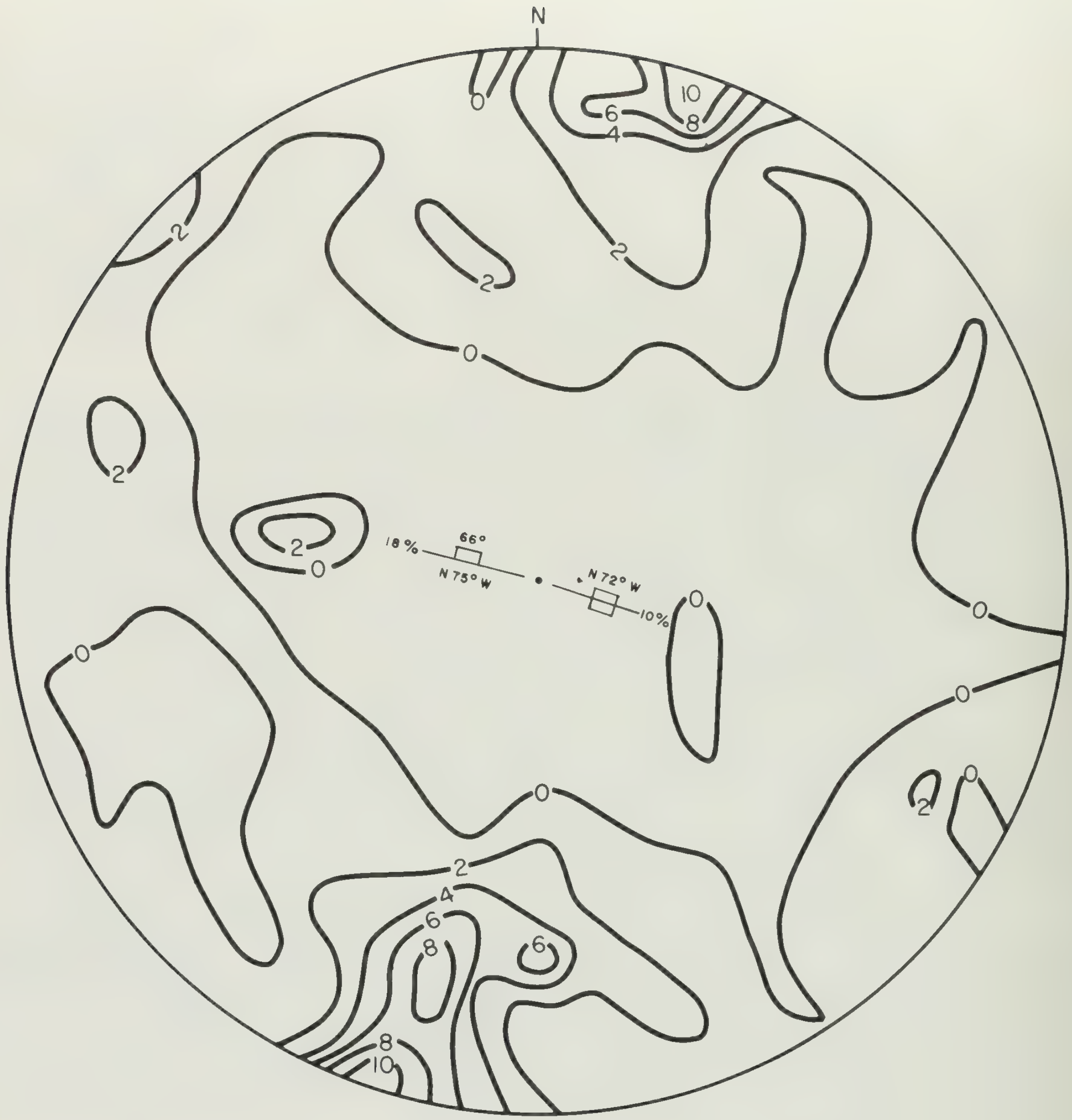
Studies of the rock quality of the Parachute Creek shales suggest the rich oil shales are less intensely fractured than the lean oil shales. This concept is supported by pump tests in the SG-1 and SG-1A core holes which determined that the vertical permeability of a zone of thin, rich oil shale is less than 0.1 millidarcies.

Structural and topographic information has been used to prepare an overburden map of the tract area. Figure VIII-6 shows the thickness of the overburden to the top of the anticipated mine roof. Overburden thickness ranges from less than 1000 feet along the major drainage to more than 1300 feet along the ridge crests. Because both the land surface and the beds slope to the north at about the same rate, changes in overburden thickness mostly reflect local variations in topographic relief.

C. Stratigraphy and Resources

1. Regional Setting

The sedimentary rocks underlying the Piceance Creek basin are more than 25,000 feet thick and range in age from Cambrian to Ouaternary. As this proposed oil shale project will affect only the Green River formation and younger rocks, discussion will be limited primarily to this formation.



Data from 39 locations on Tract C-b plotted on lower hemisphere. Contours indicate percent of all joint poles that lie within an area equal to one percent of total area of diagram.

Figure VIII–5 STEREOGRAPHIC NET CONTOUR DIAGRAM OF JOINT MEASUREMENTS

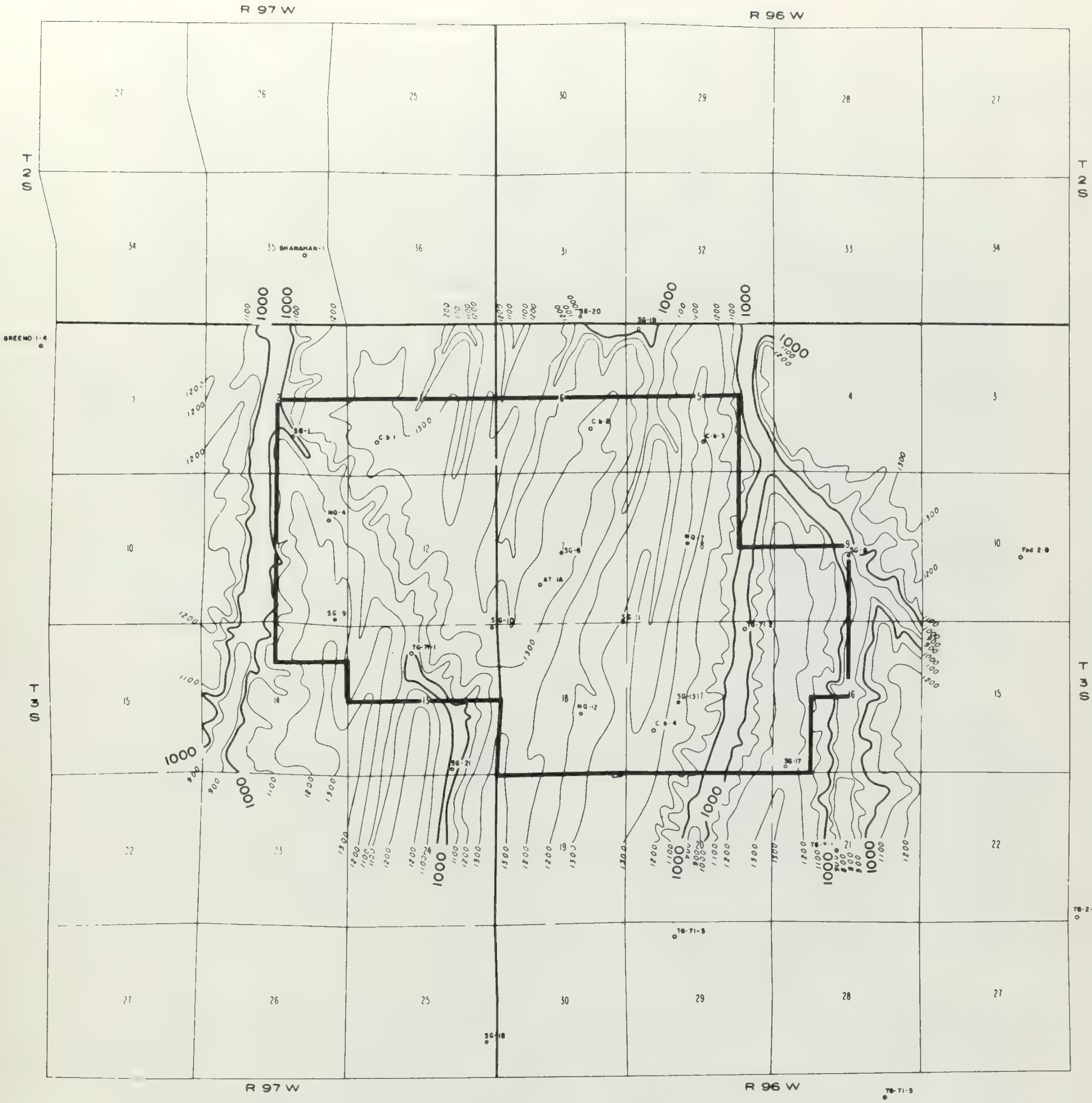


Figure VIII–6 PRELIMINARY ISOPACH OF OVERBURDEN SURFACE TO MINE ROOF TRACT C-b

The Green River formation, which contains the oil shale deposits of interest, conformably overlies the Wasatch formation of Paleocene and Eocene age. Bradley (1931) originally divided the Green River formation into four members, here listed in stratigraphically descending order: Evacuation Creek, Parachute Creek, Garden Gulch and Douglas Creek. However, Cashion and Donnell (1974) recently revised Bradley's nomenclature with the result that the name Evacuation Creek member of the Green River formation has been abandoned, and these rocks are now placed in the lower part of the Uinta formation. This revised nomenclature is used throughout this report. The regional stratigraphy of the Green River and Uinta formations is shown on Figure VIII-7.

The Uinta formation forms the surface bedrock of the central Piceance Creek basin. This unit consists mostly of light-brown and gray, silty sandstone, and tan to gray carbonaceous siltstone, with lesser amounts of marlstone and shale. In general, the marlstones are barren or contain only small amounts of organic material; however, oil shale beds up to 30 feet thick have been reported based upon drill cuttings. Throughout the Uinta formation there is much lateral variability in lithology and, except for some of the thicker marlstone units, most beds cannot be correlated over any significant distance. The original thickness of this unit cannot be determined because erosion has removed the upper part. However, the formation reaches a maximum thickness of more than 1500 feet in the north-central part of the basin.

The Parachute Creek member of the Green River formation is composed almost entirely of organic-rich marlstone (oil shale). It ranges in thickness from less than 900 feet around the southern and western margin of the basin to more than 1900 feet in the north-central part of the basin. The richness of the Parachute Creek oil shales varies both vertically and laterally. Around the margin of the basin, rich oil shale (greater than 25 GPT) is restricted to a unit in the upper part of the member, about 100 feet or less in thickness, called the Mahogany zone. This rich unit persists over most of the basin. The Mahogany zone generally thickens toward the north-central part, where it reaches a maximum thickness of more than 200 feet.

Oil shale in the lower part of the Parachute Creek member (below the Mahogany zone) is best developed in the north-central part of the basin. This section, which has been referred to as the "lower oil shale zone," reaches a maximum thickness of about 1200 feet and has a maximum richness in excess of 30 GPT near the basin depocenter. Rich oil shale units in the "lower oil shale zone" thin and grade laterally to leaner oil shale toward the margin of the basin. At the outcrop, the "lower oil shale zone" averages less than 10 GPT. Key rich units within the "lower oil shale zone" recently have been given letter and number designations (R-2 through R-6) and have been correlated over much of the basin.

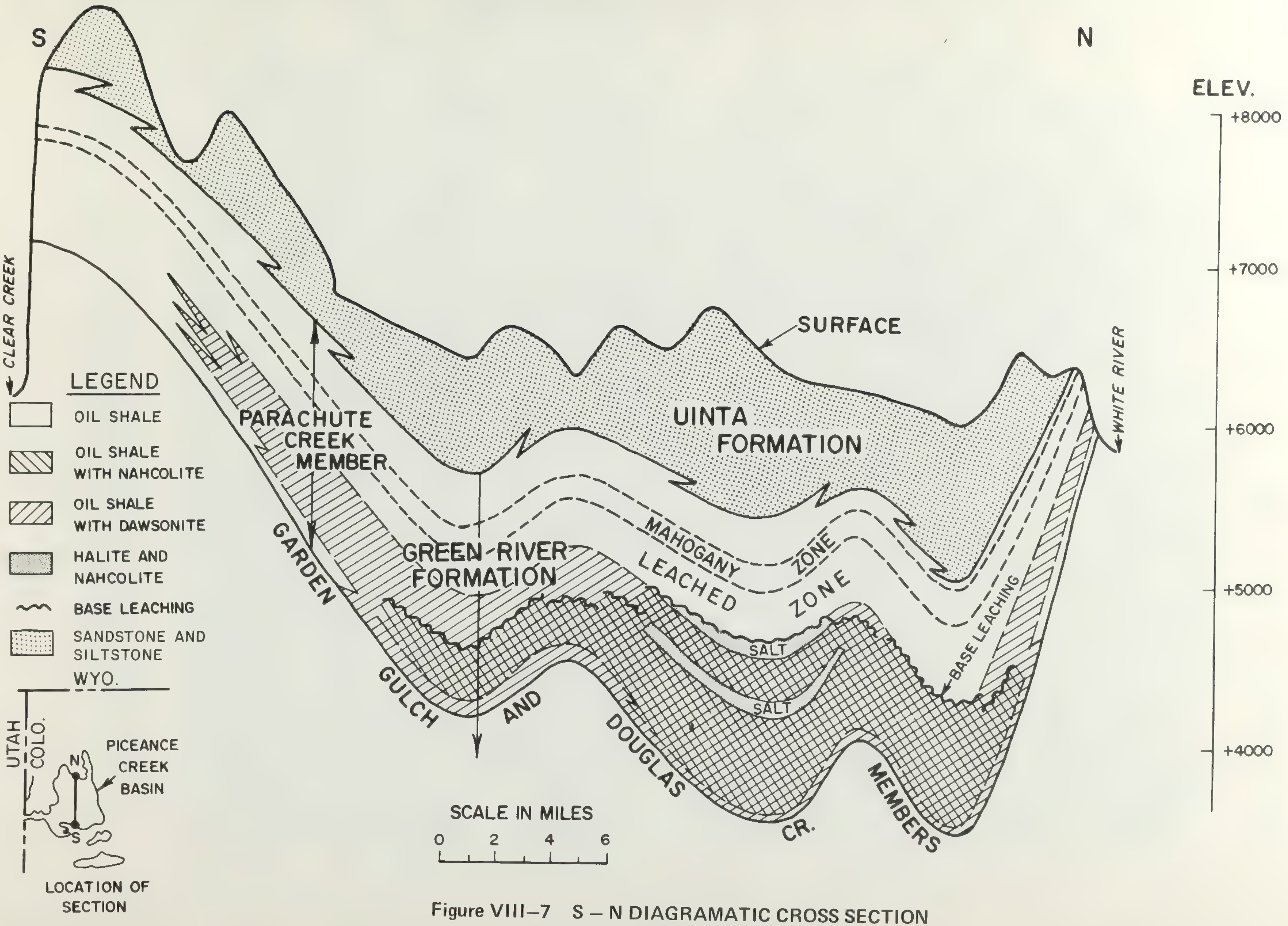
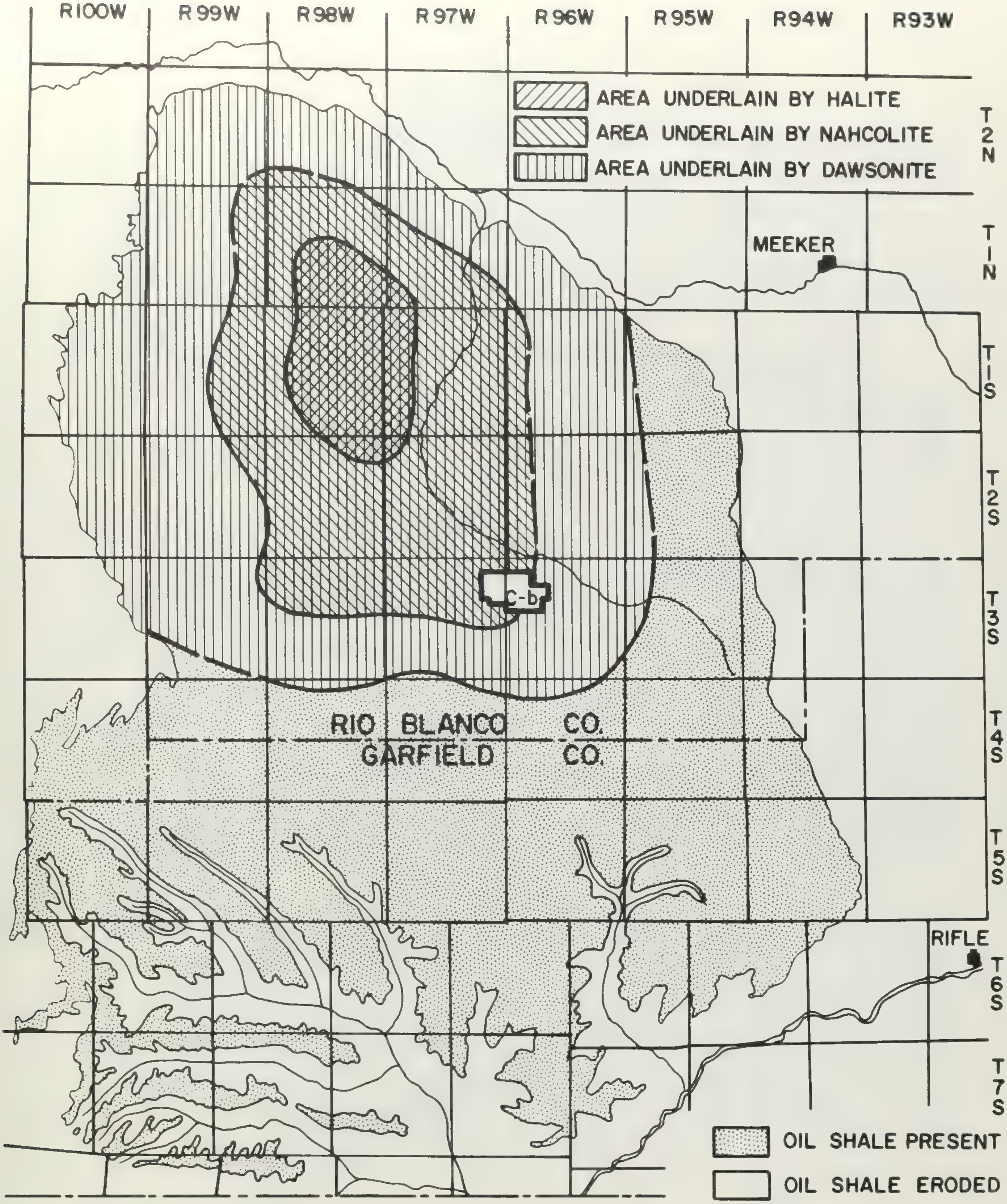


Figure VIII—7 S — N DIAGRAMATIC CROSS SECTION THRU PICEANCE CREEK BASIN

In the north-central part of the basin, the "lower oil shale zone" contains large amounts of the saline minerals nahcolite ($NaHCO_3$), dawsonite ($NaAl(OH)_2CO_3$) and halite ($NaCl$)(Figure VIII-7 and VIII-8). In the vicinity of the basin depocenter the nahcolite-bearing section is present over an interval up to 900 feet thick, which averages as much as 28 weight percent nahcolite. Nahcolite mostly occurs as coarsely crystalline radiating nodules 1-3 inches in diameter, but occasionally is found in beds. The nahcolite-bearing oil shales decrease in thickness and nahcolite content toward the margin of the basin (Figure VIII-8). Halite is mostly concentrated in two zones about 250 feet apart. The "upper salt zone" has a maximum thickness of about 160 feet and the "lower salt zone" has a maximum thickness of about 120 feet. Both salt zones are comprised of varying amounts of interbedded halite, nahcolite and oil shale. The salt zones, which are much more restricted in lateral extent than the nahcolite-bearing section, thin and pinch out toward the basin margin (Figure VIII-8). Dawsonite is generally confined to the interval between the base of the "upper salt zone," or its stratigraphic equivalent, and the base of the Parachute Creek member. Dawsonite normally occurs as minute crystals, five microns or less in size, disseminated throughout the oil shale. Over short intervals dawsonite may comprise as much as 25 weight percent of the rock, but over long intervals concentrations generally average 10 weight percent or less. Dawsonite diminishes or disappears toward the margin of the basin due to nondeposition (Figure VIII-8).

The beds between the nahcolite-bearing section and the lower part of the Mahogany zone are commonly referred to as the "leached zone." The leached zone is characterized by solution cavities, open fractures, local breccias and intervals of porous earthy marlstone. Substantial quantities of nahcolite, which were originally present in this interval, have subsequently been dissolved and removed by ground water. "Leached zone" rocks commonly are highly porous and permeable.

The Garden Gulch and Douglas Creek members underlie the Parachute Creek member. Because the criteria used to define the boundary between these two members at the outcrop do not apply in the subsurface, these members are usually combined in regional geologic discussions. The Garden Gulch and Douglas Creek members are chiefly composed of fine-grained clastic rocks. In the central part of the basin, the lower part of the combined unit is composed of interbedded mudstone, siltstone and clay (illite) shale. The amount of clay shale gradually increases upward through this part of the section, and in the upper part of the combined section it is interbedded with moderately rich oil shale. The two members have a combined thickness ranging from 300 feet near the center of the basin to more than 1000 feet in places along the outcrop. The thickening of the combined unit toward the outcrop is mainly attributable to the additional amounts of silt and sand that have been added to the section.



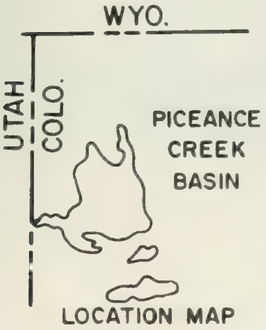


Figure VIII–8 SALINE MINERAL DISTRIBUTION
NORTHERN PICEANCE CREEK BASIN

2. Tract C-b

The Tract is located in the souteast part of the Piceance Creek drainage system. The Tract contains a sedimentary sequence that is intermediate between the section present at the outcrop and the section near the basin depocenter. The Uinta formation comprises the surface bedrock over the entire Tract. This unit, which consists mostly of interbedded sandstone, siltstone and marlstone, ranges from about 400 to 900 feet in thickness across the Tract. Figure VIII-9 is a surface map of the Tract and surrounding area showing key units in the Uinta formation.

The Parachute Creek member of the Green River formation underlies the Uinta formation. Composed almost entirely of organic marlstone (oil shale) of varying richness, this unit averages about 1600 feet in thickness beneath the Tract. As shown in Figure VIII-10, the Parachute Creek member has been subdivided into a number of units based on richness differences and other physical properties.

The Mahogany zone is the unit of principal interest beneath the Tract because it contains the richest oil shale section in this part of the basin. Here, the Mahogany zone ranges from 174 to 187 feet in thickness. The Mahogany zone is bounded at the top by a lean oil shale unit about 15 feet in thickness known as "A" Groove and is bounded at the base by a lean oil shale unit 20 feet in thickness called "B" Groove.

The preferred mine zone of primary interest at this time is an interval of rich oil shale within the Mahogany zone with an average thickness of 77 feet. The top of this interval is generally encountered about 35 feet below the base of "A" Groove and ranges in thickness from 74 to 83 feet. For planning purposes, the preferred mining interval has been divided into three subdivisions, as shown in Figure VIII-11. The oil shale resource within each of these subdivisions as well as the total mine interval is given in Table VIII-1.

The oil shale section between the base of "B" Groove and the base of the Parachute Creek member is customarily referred to as the "lower oil shale zone." As previously noted, in the north-central part of the basin this interval is comprised almost entirely of rich oil shale. However, the Tract is peripheral to the basin depocenter and the lower oil shales here are much leaner in comparison to the basin center. Figure VIII-11, which is an example log for the Tract, shows the distribution of oil shale richness in the "lower oil shale zone." In general, these oil shale zones are too lean and too intensely fractured to be mined. The R-4 zone appears to be the only interval in the "lower

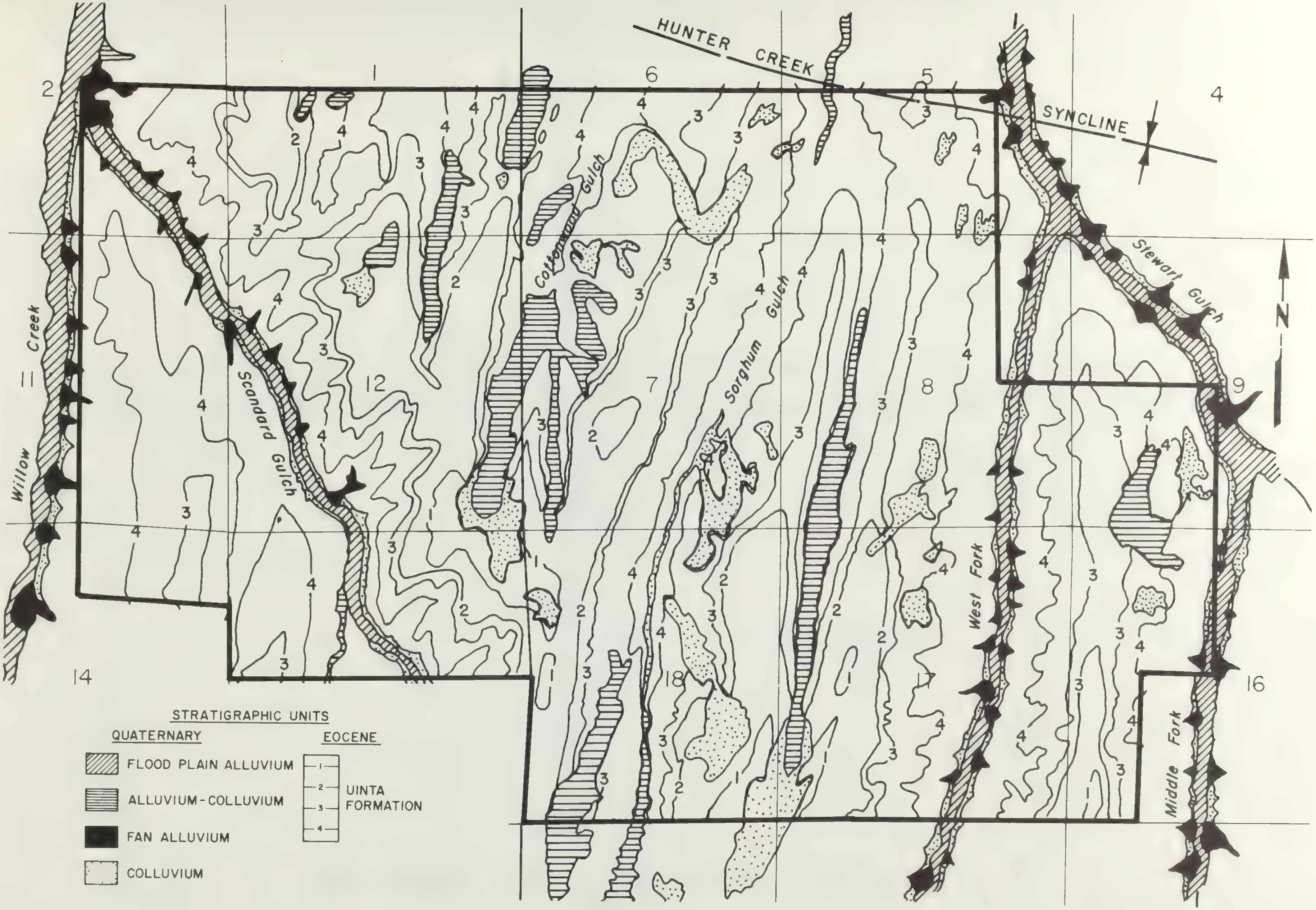


Figure VIII–9 SURFACE GEOLOGIC MAP
TRACT C-b AND VICINITY

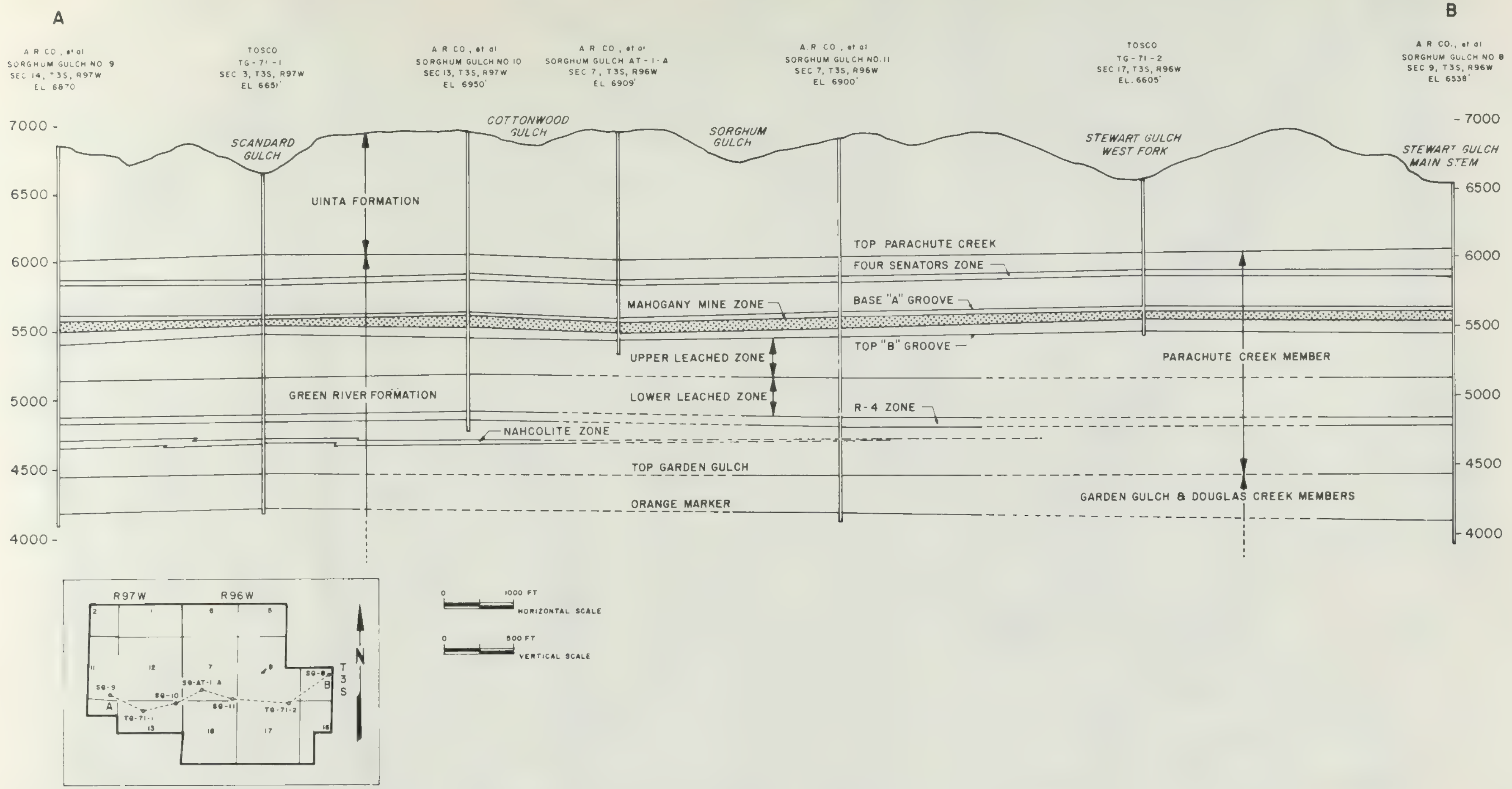


Figure VIII—10 EAST-WEST STRATIGRAPHIC CROSS SECTION TRACT C-b

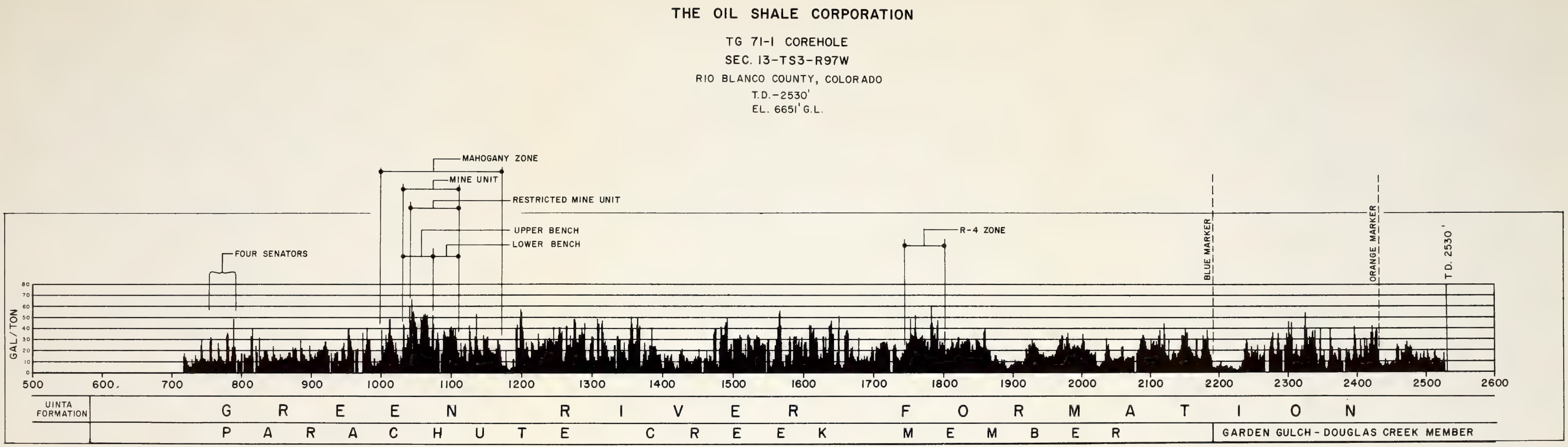


Figure VIII—11 TYPICAL RICHNESS HISTOGRAM FOR TRACT C-b

Table VIII–1 POTENTIALLY MINEABLE OIL SHALE RESOURCES
TRACT C-b

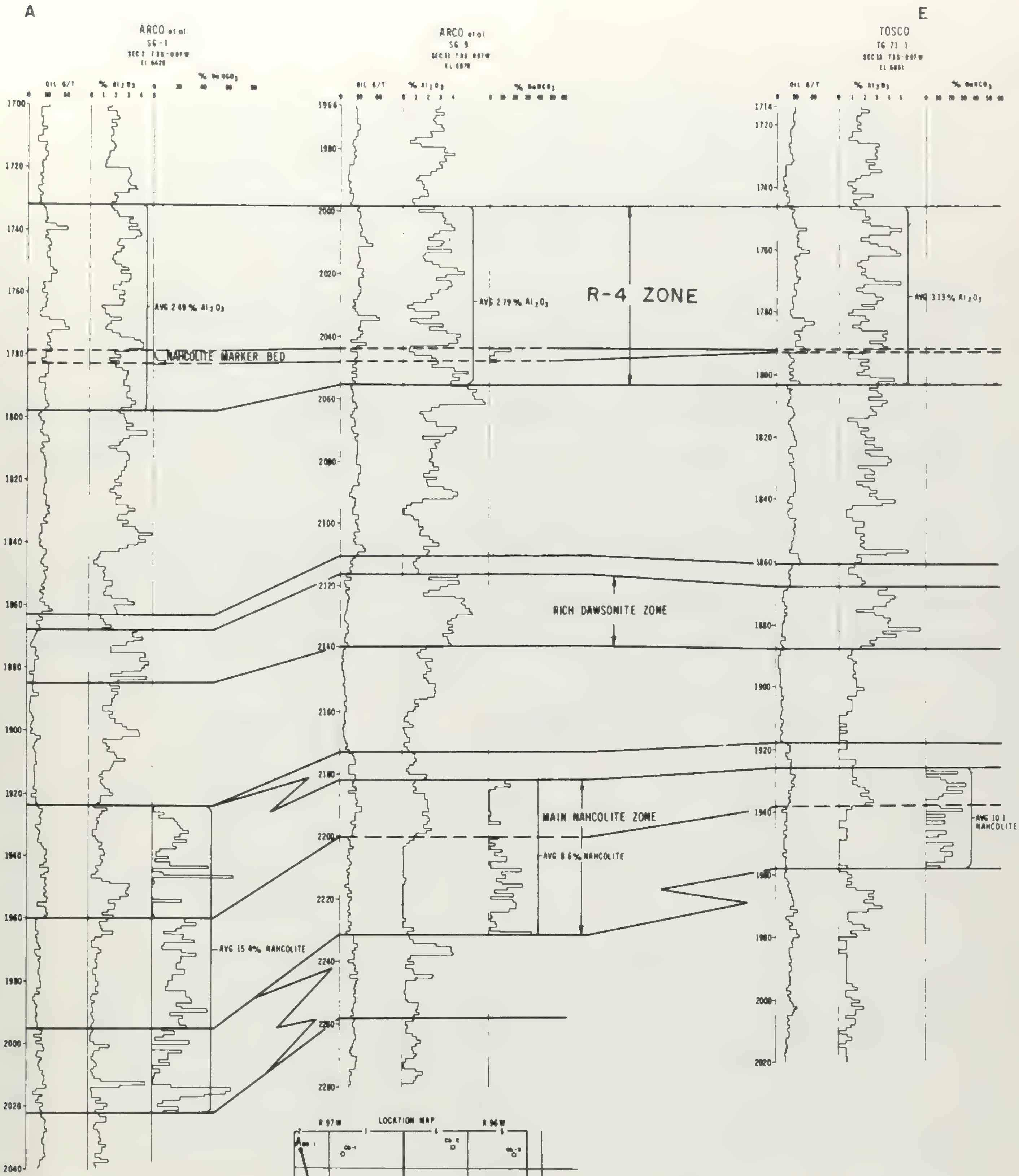
	Average Grade GPT	Range GPT	Average Thickness Feet	Range Feet	Resource Bbls. x 10^6
MAHOGANY ZONE					
Mine Unit	36.0	32.2-38.6	77	74-83	939.93
Restricted Mine Unit	36.6	32.4-39.8	68	65-73	841.69
Upper Bench	38.7	34.0-44.2	45	42-50	581.32
Lower Bench	32.3	29.4-33.7	31	28-35	358.61
R-4 ZONE	30.0	28.0-33.0	55	53.57	582.29

oil shale zone" beneath the Tract with adequate grade and rock quality to have some future commercial potential. However, present plans do not include the mining of this zone. The oil shale resource in the R-4 zone is shown in Table VIII-1.

In Table VIII-1 the maximum shale oil resource for Tract C-b is indicated to be 1.52 billion barrels of oil, which is the total of the 77-foot mine zone within the Mahogany zone and the 55-foot R-4 zone below the Mahogany zone. In the "Final Environmental Statement For the Prototype Oil Shale Leasing Program", the total shale oil resource is estimated to be 723 million barrels of oil. The government's figure is apparently based on a conceptual plan to mine a 50-foot unit within the Mahogany zone and a 50-foot unit below the Mahogany zone. Both units are assumed to average 30 gallons of oil per ton.

Both nahcolite and dawsonite are present beneath the Tract. Nahcolite is occasionally found in nodule form within the Mahogany zone, but in such small amounts that it affords no apparent commercial potential. The zone of greatest nahcolite concentration on the Tract is found in the lower part of the Parachute Creek section, about 120 feet below the base of the R-4 zone (Figure VIII-12). This nahcolite-bearing interval is present only in the western half of the Tract. It ranges from a maximum thickness of 98 feet in the SG-1 core hole, to six feet in the SG-11 core hole. Just east of SG-11 the zone is lost due to nondeposition. The amount of nahcolite present within this zone varies from a maximum of 15.4% in SG-1 to zero on the east side of the Tract. An estimated 30,000,000 tons of nahcolite are present on the Tract within the main nahcolite zone (Table VIII-2). The main nahcolite zone occurs in moderately lean oil shale (i.e., shale that will average on the order of 20 GPT). The low concentration of nahcolite, plus the presence of lean shale, eliminates this zone as an interval of interest in the foreseeable future. Nahcolite is also present in small amounts in the R-4 zone on the west side of the Tract (Figure VIII-12).

Dawsonite, an alumina-bearing mineral, is found throughout the Mahogany zone. However, as the concentration of potentially recoverable alumina (Al_2O_3) in this part of the section averages less than 1%, dawsonite extraction is not economically feasible. Within the "lower oil shale zone" of the Parachute Creek section, there are numerous thin intervals (usually less than 10 feet thick) which average about 5% alumina. Figure VIII-10 shows the vertical distribution of the richer alumina-bearing sections within a 300-foot interval in the "lower oil shale zone."



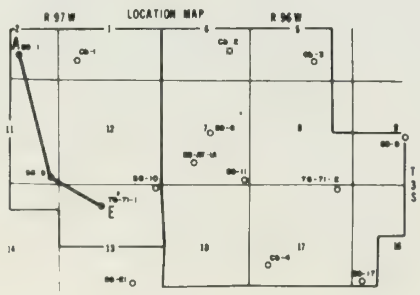


Figure VIII–12 NORTH-SOUTH STRATIGRAPHIC SECTION A-E NAHCOLITE-DAWSONITE (Al_2O_3) RESOURCES

Table VIII–2 NAHCOLITE AND DAWSONITE RESOURCES
TRACT C-b

NAHCOLITE RESOURCES

Zone	Extent (Acres)	Average Grade (%)	Average Thickness (Feet)	Resource (Tons)
Main Nahcolite Zone	3460±	8%	35±	30,000,000

DAWSONITE RESOURCE AS ALUMINA (Al_2O_3)

R-4 Zone	5093	2.5%	56'	20,000,000
Rich Dawsonite Zone	5093	3.5%	20'	12,000,000

Because dawsonite might enhance the future economic potential of the R-4 zone beneath the Tract, special attention was given to the alumina content in this interval (Figure VIII-13). In the R-4 zone, the alumina percentage ranges from a high of 3.13% in the TOSCO TG-71-1 to a low of 1.79% in the SG-17. The dawsonite resource of the R-4 zone (Table VIII-2) contains about 20,000,000 tons of alumina, or about 4000 tons of alumina per acre.

Another alumina zone of interest occurs about 50 feet stratigraphically below the base of the R-4 zone (Figure VIII-12). This rich dawsonite zone ranges from 17 to 23 feet thick on the Tract and averages about 3.5% alumina with a range from 2.70 to 3.91%. This zone has a rather uniform thickness across the basin, but increases in alumina content to the north and west of the Tract. As this alumina-rich zone occurs in a lean oil shale zone that averages approximately 10 GPT, it has no apparent economic potential. There are about 12,000,000 tons of alumina in this zone (Table VIII-2).

Samples of the Parachute Creek member from four core holes have been analyzed to determine concentrations of antimony (Sb), arsenic (As), boron (B), cadmium (Cd), flourine (F), mercury (Hg) and selenium (Se). Except for the concentrations of flourine and arsenic, which gradually increase with depth, no strong correlations between concentrations of elements and depth or stratigraphic zone are indicated. The range of concentrations of these base elements is as follows:

	Concentration (PPM)	
Element	Maximum	Minimum
Antimony	3.0	1.0
Arsenic	125.0	10.0
Boron	300.0	10.0
Cadmium	0.7	0.5
Flourine	3400.0	600.0
Mercury	1.3	0.02
Selenium	10.0	2.0

The only two trace elements in the oil shale that also occur in significant amounts in the ground water are fluorine and boron. Fluorine may reach a concentration of 45 PPM in highly saline water below the R-4 zone, but normally does not exceed 20 PPM. Boron concentration in ground water may be as high as 47 PPM in saline water, but is usually less than 3 PPM. None of the trace elements occurs in significant amounts in the surface waters of the basin, except fluorine, which is present in low concentrations. Consequently, it can be assumed that, except as noted, these elements, are not released in large amounts to the ground and surface water. (See Section IX on Hydrology and Water Quality.)

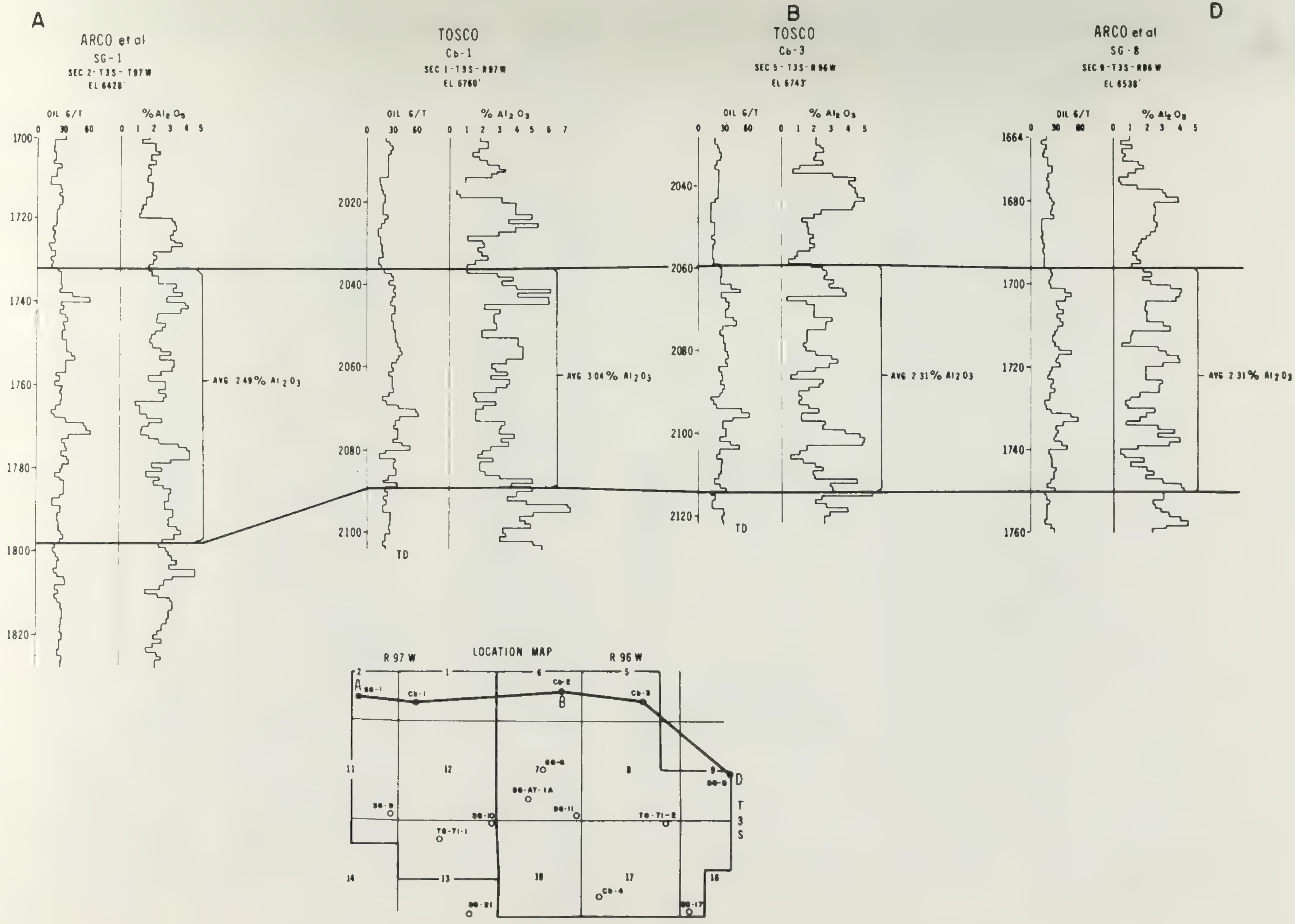


Figure VIII—13 EAST-WEST STRATIGRAPHIC SECTION A-B-D DAWSONITE (Al_2O_3) RESOURCES

Minor amounts of nahcolite, which were originally present in the upper one-half of the "lower oil shale zone," have been removed by percolating groundwaters forming a "leached zone." In comparison with the central part of the basin, the "leached zone" beneath the Tract is thicker but appears to have considerably less interconnected void space. Because of the scarcity of nahcolite in the section, it is impossible to define the base of the "leached zone" underneath most of the Tract. (See Sub-surface Hydrology, Section IX.B.)

The Garden Gulch and Douglas Creek members underlie the Parachute Creek member. These units, which are not differentiated on the Tract, have a combined thickness of about 500 feet. The Garden Gulch-Douglas Creek members are mostly comprised of interbedded true shale and organic marlstone. Some poorly developed siltstones and sandstone are present near the base of the combined unit.

Stream alluvium is present in narrow bands along the main drainages overlying the Uinta formation. The thickness of this alluvial veneer is generally less than 100 feet.

D. Geologic Hazards

Detailed surface geologic mapping of the Tract and vicinity was conducted to identify existing natural hazards such as landslides, rock-fall areas, slump fractures, soil creep and mud flow areas. Minor soil creep and slump occurs near the heads of several tributaries along Willow Creek.

Areas of Quaternary deposits, which include flood-plain alluvium, fan alluvium, colluvium and mixed alluvium and colluvium, have the greatest potential for erosion. These areas are shown on Figure VIII-9.

At present, erosion appears to be most severe at the heads of some of the smaller gulches. The alluvial material is locally incised 20 to 30 feet below the floors of the gulches, and the heads of the gulches exhibit slopes on the order of 45°.

Significant flooding will generally be restricted to established stream flood plains, which are defined by the distribution of flood plain alluvium. Sheet flooding will essentially occur everywhere.

E. Oil and Gas Development

The nearest significant gas production is from the Douglas Creek sands and various Wasatch sands on the Piceance Creek anticline about three miles northeast of the Tract. Gas was discovered in 1955 in the Douglas Creek and Wasatch sands about 2-1/2 miles east of the Tract, but this area has no history of sustained production. No significant oil production has occurred in the Piceance Creek basin.

Some drilling on the Tract has penetrated as deep as the Douglas Creek member of the Green River formation, which lies about 1500 feet below the Mahogany zone mine interval. No indication of commercial liquid or gaseous hydrocarbons was found in these tests. Gas that has been encountered on the Tract appears to be present in solution in the ground water. In the upper aquifer, the ground water is capable of containing approximately 100 times the quantity of gas that was actually produced with water during pump tests. In the lower aquifer, the ground water is capable of containing approximately four times the quantity of gas produced with water during the pump tests.

The Rio Blanco Federal Oil and Gas Unit encompasses the Tract. A portion of the lands within the Unit, including part of the Tract, are covered by a Unit Operating Agreement between USGS and the owners of oil and gas interests. The agreement stipulates that:

"No wells will be drilled for oil or gas at a location which, in the opinion of the Supervisor, would result in undue waste of the oil shale deposits in the Parachute Creek member of the Green River Formation or would constitute a hazard to or unduly interfere with mining or other operations being conducted for the mining and recovery of said deposit or the extraction of oil from said deposit."

IX. Hydrology and Water Quality

A. Surface Hydrology

1. Setting

a. Colorado River Basin

The Tract is located in the Upper Colorado River basin, as illustrated in Figures IX-1 and IX-2. The Colorado River basin drains an area within the United States of 242,000 square miles, or approximately one-twelfth the area of the contiguous 48 states. The Upper Colorado basin includes the drainages of the Colorado River between Lee's Ferry, Arizona, and the Great Divide basin in south-central Wyoming, or approximately 109,500 square miles. The basin is divided into three subregions: Upper Main Stem, Green and San Juan. The Upper Main Stem subregion includes the areas of oil shale deposits in the Piceance Creek basin.

The water supply in the Upper Colorado basin comes mostly from winter precipitation in the mountains. Yearly stream-flow peaks coincide with the spring snowmelt in the high country. During the summer, precipitation in the mountains is mostly utilized by vegetation. In the upper basin, 77% of the area receives less than 12 inches of annual precipitation. Areas of limited precipitation are located mostly in the lower elevations. In the mountains, ground water and surface water are closely related, and there is sufficient precipitation for aquifer recharge.

Calculation of an annual water budget for the Upper Colorado River basin, using a basin-wide average of 15.88 inches of precipitation falling on the 109,500-square-mile area shows a total estimated precipitation of 92,739,000 acre-feet. Of this amount, the greatest water loss from the basin is by evapotranspiration (77,748,000 acre-feet). Outflow from the upper basin accounts for 12,733,100 acre-feet, and consumptive use by irrigation amounts to 1,759,100 acre-feet. The remaining amounts are diverted across the Continental Divide to other watersheds or are lost to industrial or domestic consumptive use.

Historically, the Colorado River has carried a large load of dissolved minerals. Natural forces and many human activities contribute to a salinity concentration in the Colorado River which is considerably higher than the levels in most other major rivers. Generally, the salinity of the river increases from its headwaters to its mouth. This increase in salinity is the result of two basic processes--salt loading (adding salts) and salt concentrating (removing water).

Detrimental effects caused by rising salinity levels in the Lower Colorado basin have resulted in international treaty commitments with

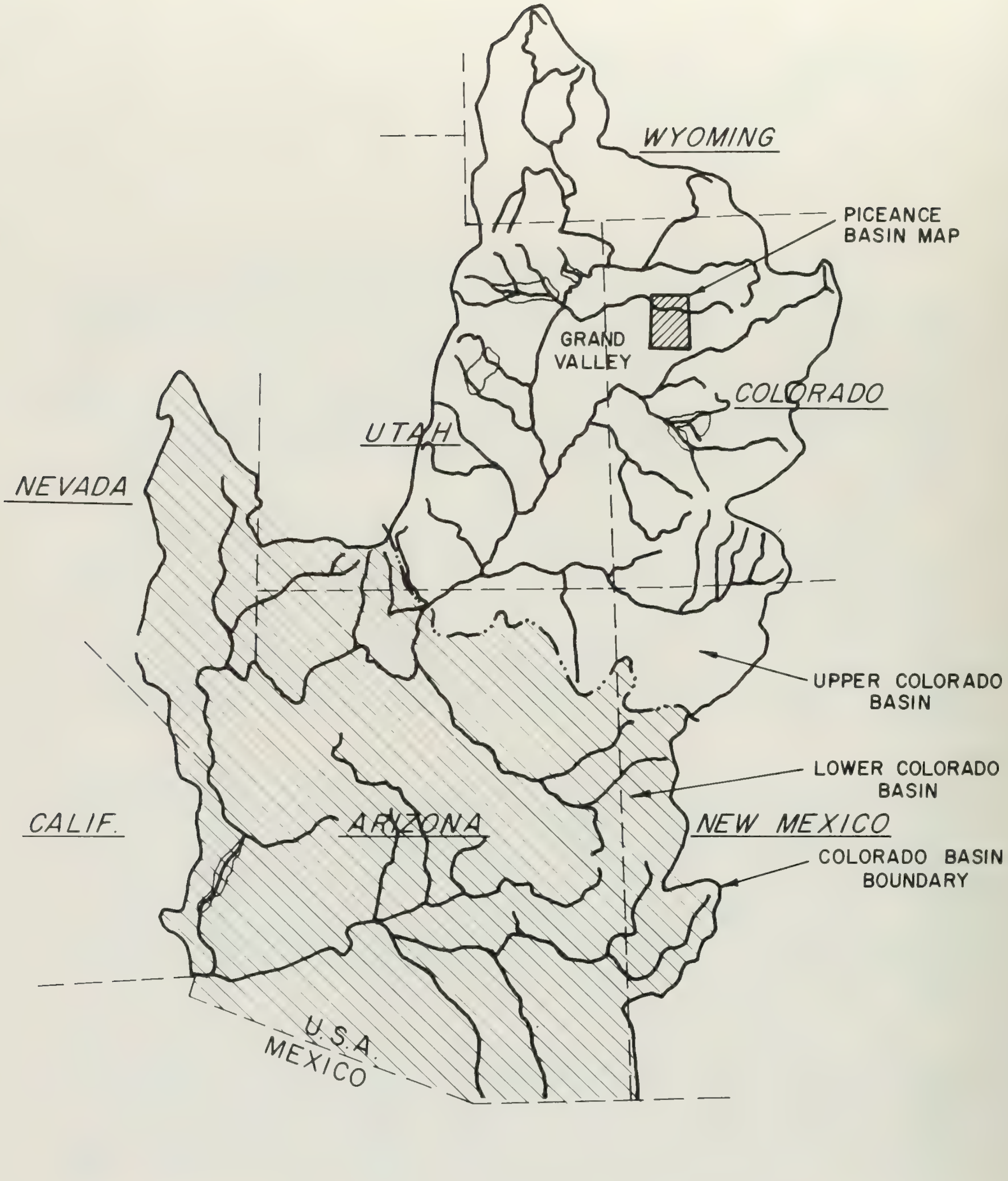


Figure IX–1 COLORADO RIVER BASIN

Mexico and in the formation of the Colorado River Salinity Control Forum, composed of water-resource and water-quality representatives from the seven Colorado River basin states of Arizona, California, Colorado, Nevada, New Mexico, Utah and Wyoming. This forum is charged with developing water-quality standards for salinity to meet an Environmental Protection Agency regulation requiring that salinity levels be maintained at or below the levels existing in 1972. The 1972 level for the Colorado River has been defined as 723 milligrams per liter (mg/l), total dissolved solids (TDS), measured below Hoover Dam.

The drainages on the Tract are tributary to Piceance Creek, which flows into the White River, 17 miles west of Meeker, Colorado (Figure IX-2). The White River flows into the Green River at Ouray, Utah; the Green River flows into the Colorado River southwest of Moab, Utah. Average annual flow of the Green River measured at Green River, Utah, is 4,187,000 acre-feet with 456 mg/l TDS. Average annual flow of the White River near Watson, Utah, is 554,500 acre-feet with 439 mg/l TDS. Piceance Creek, as it enters the White River, contains an average of approximately 2000 mg/l TDS with an average annual flow of 14,500 acre-feet.

b. Piceance Creek

The USGS has recently completed a hydrologic investigation entitled: "Simulated Effects of Oil Shale Development on the Hydrology of the Piceance Basin, Colorado" (Weeks, et al., 1974). Much of the investigation was devoted to describing the surface hydrology of the basin, particularly the stream-flow and water-quality characteristics of Piceance Creek. The parts of this study describing the general setting are summarized below. Subsequent work conducted as part of the Tract investigation is discussed later in this section.

Piceance Creek originates in the vicinity of the Grand Hogback, north of Rifle, Colorado, and flows west and northwest to the White River. It follows the southern edge of the Piceance Creek anticline as it traverses the oil shale areas. Yellow Creek is the other major drainage in the basin, but that system would not be affected by Tract operations.

Stream flow from the Piceance Creek drainage basin is typical of those regions where the primary source of stream flow is snowmelt. Precipitation for the months of November through March is stored in the snowpack at the higher altitudes of the basin and becomes available for recharge and runoff as daily temperatures and solar radiation increase in the spring. Snowmelt produces a period of high stream flow, starting in March or April and continuing through June or July. Stream flow for the remainder of the year is maintained almost totally by ground-water discharge, which moves through the alluvium into the stream channels or appears as springs along the valley floors. Evapotranspiration rates are high during the summer and most of the precipitation that occurs during this period is evapotranspired. Only high-intensity thunderstorms, which are usually limited to a small area, produce any significant contributions to summer stream flow.

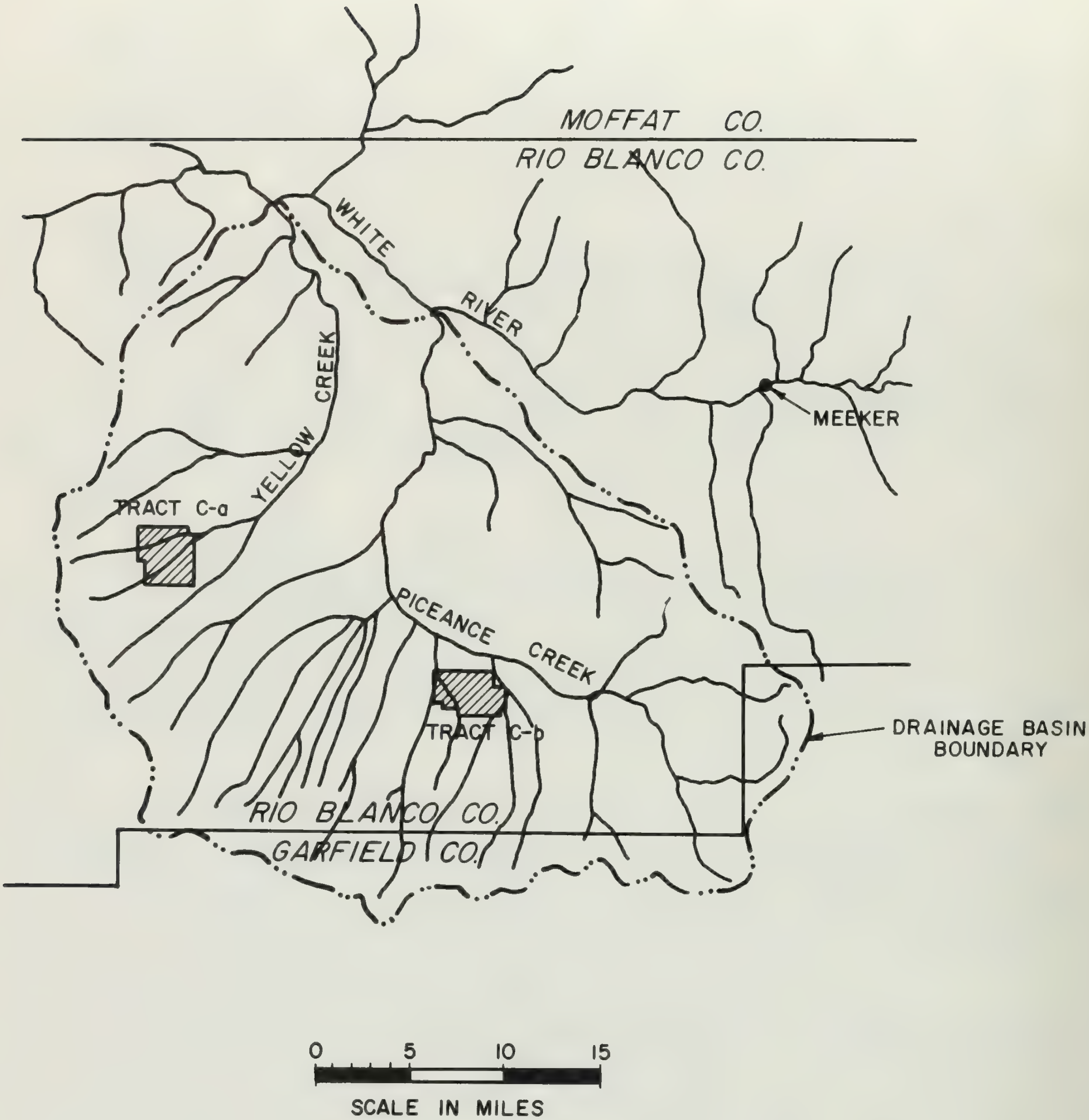


Figure IX–2 PICEANCE CREEK BASIN AND TRACTS C-a AND C-b

The USGS has maintained several stream-flow gauging stations on Piceance Creek for varying periods. Figure IX-3 shows the locations of these stations. Rio Blanco is shown as Station 1. The runoff characteristics of the Piceance Creek basin are described primarily on the basis of the gauging station records for Piceance Creek below Ryan Gulch (Figure IX-3, Station 3) and Piceance Creek at the White River (Figure IX-3, Station 4). The latter station is located at the mouth of Piceance Creek and reflects the total discharge from the basin. The gauge below Ryan Gulch, which has the longest record in the basin, measures a major part of the runoff from the basin. Its records run concurrently with the Piceance Creek gauge at the White River, and from it the shorter-period record can be extended.

The measured and adjusted annual runoff for the gauging stations on Piceance Creek below Ryan Gulch and on Piceance Creek at White River are shown in Figure IX-4. The adjusted runoff equals the amount measured, plus the diversion around the gauge, as estimated by the Colorado Division of Water Resources. For the 9 years of record, the adjusted mean annual runoff at the gauge below Ryan Gulch is 12,850 acre-feet; it is 14,910 acre-feet for the 5 years of record at the gauge at the White River.

Mean daily stream flow reaches a peak during the snowmelt period of March through June, recedes through the summer months, and is normally at a minimum during the winter months. This pattern is shown by the hydrograph for Piceance Creek at Rio Blanco in Figure IX-5. Stream flow at this gauge is only slightly affected by irrigation. Weekly flow records from other springs and streams in the Piceance Creek basin show a similar pattern.

The hydrographs of average monthly discharge shown in Figure IX-5 for Piceance Creek below Ryan Gulch and Piceance Creek at White River show a somewhat different pattern because of the effects of irrigation diversion. Approximately 5100 acres are irrigated above the gauge at the White River; this includes 4000 acres above the gauge below Ryan Gulch. The low flows in April at both gauges indicate that, in the early part of the irrigation season, large volumes of water are diverted.

Chemical analyses of water samples collected from the water-quality locations shown on Figure IX-6, indicate that the surface waters in the lower reaches of Piceance Creek can be classified as a mixed bicarbonate type. The TDS increases to about 700 mg/l, just upstream of the Tract, and then further increases to about 950 mg/l downstream. The TDS eventually measures approximately 2000 mg/l at the mouth of Piceance Creek. The change in chemical composition in the downstream direction with respect to the major cations and anions is shown in Figure IX-7.

In addition to changes with movement downstream, the concentration of dissolved solids varies throughout the year. Figure IX-8 shows the seasonal variation in the concentrations of dissolved solids and discharge measured at the gauge on Piceance Creek at White River (Figure IX-5, Station 4) during the 1972 water year. During the high-flow period,

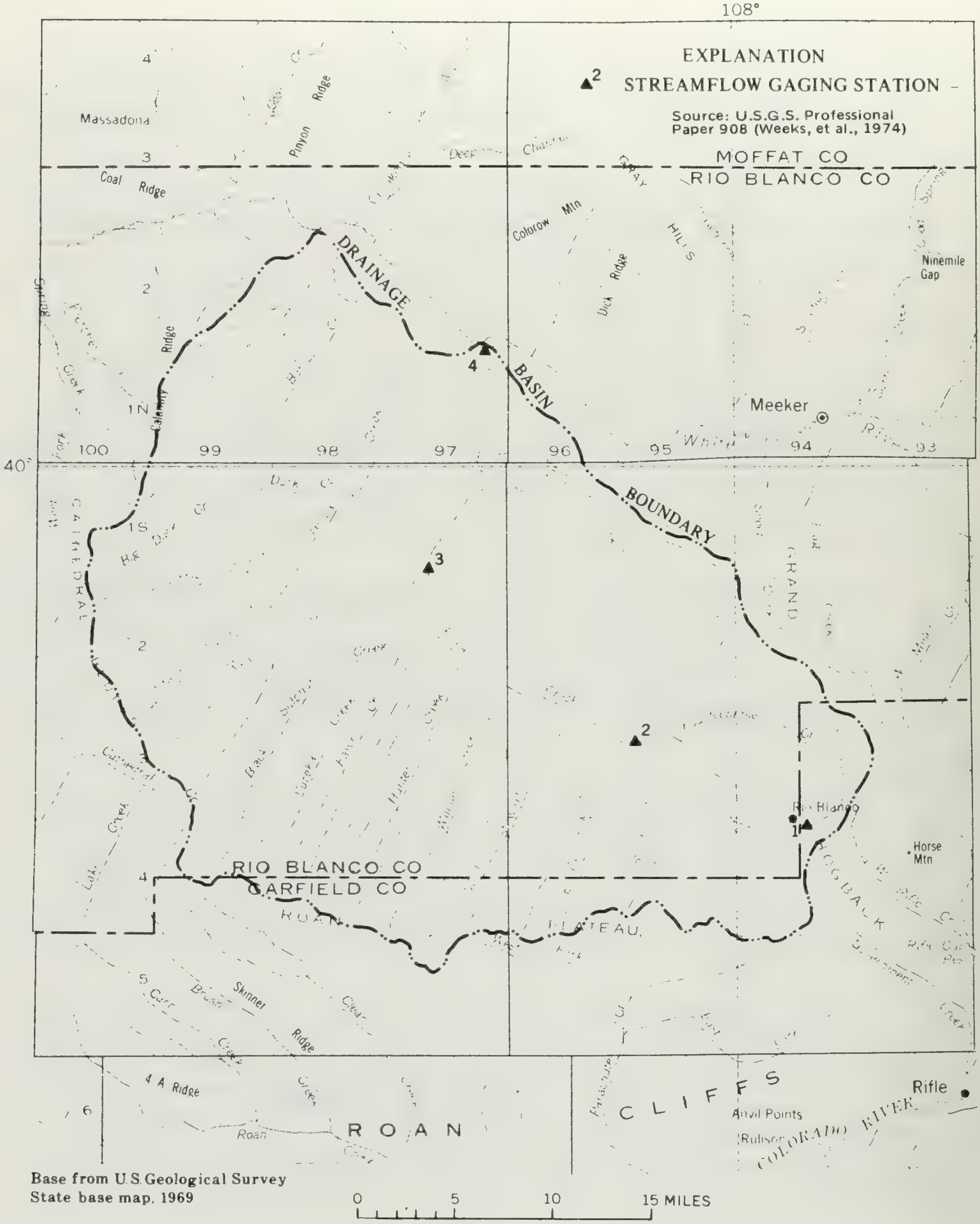
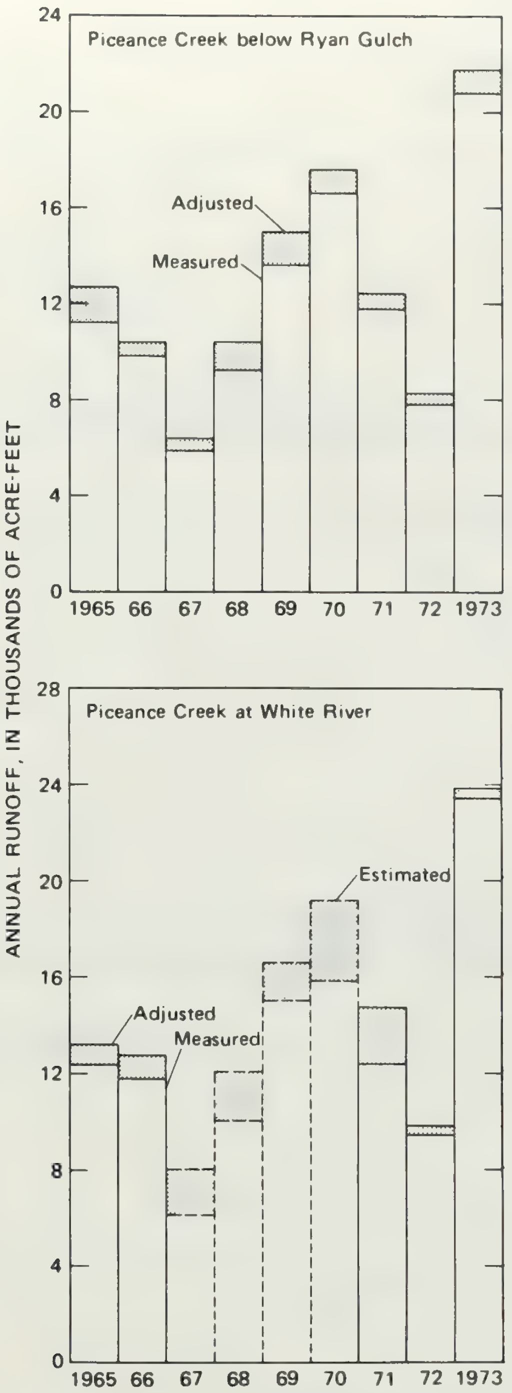


Figure IX–3 LOCATION OF U.S.G.S. STREAMFLOW GAUGING STATIONS ON PICEANCE CREEK



Source: U.S.G.S. Professional Paper 908 (Weeks, et al., 1974)

Figure IX–4 ANNUAL ADJUSTED RUNOFF FROM PICEANCE CREEK BELOW RYAN GULCH AND AT WHITE RIVER

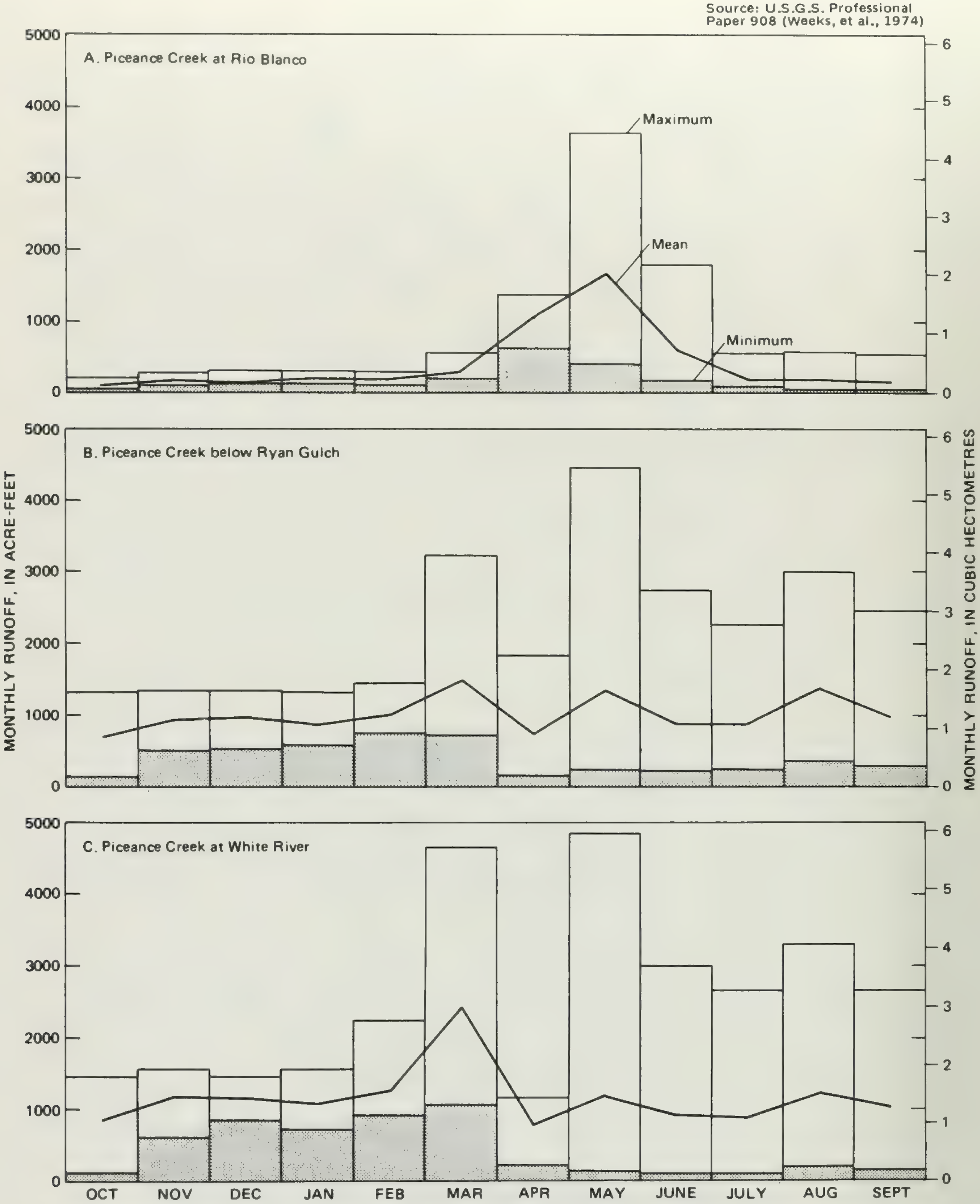


Figure IX–5 MAXIMUM, MINIMUM, AND MEAN MONTHLY RUNOFF FROM PICEANCE CREEK AT RIO BLANCO, BELOW RYAN GULCH, AND AT WHITE RIVER

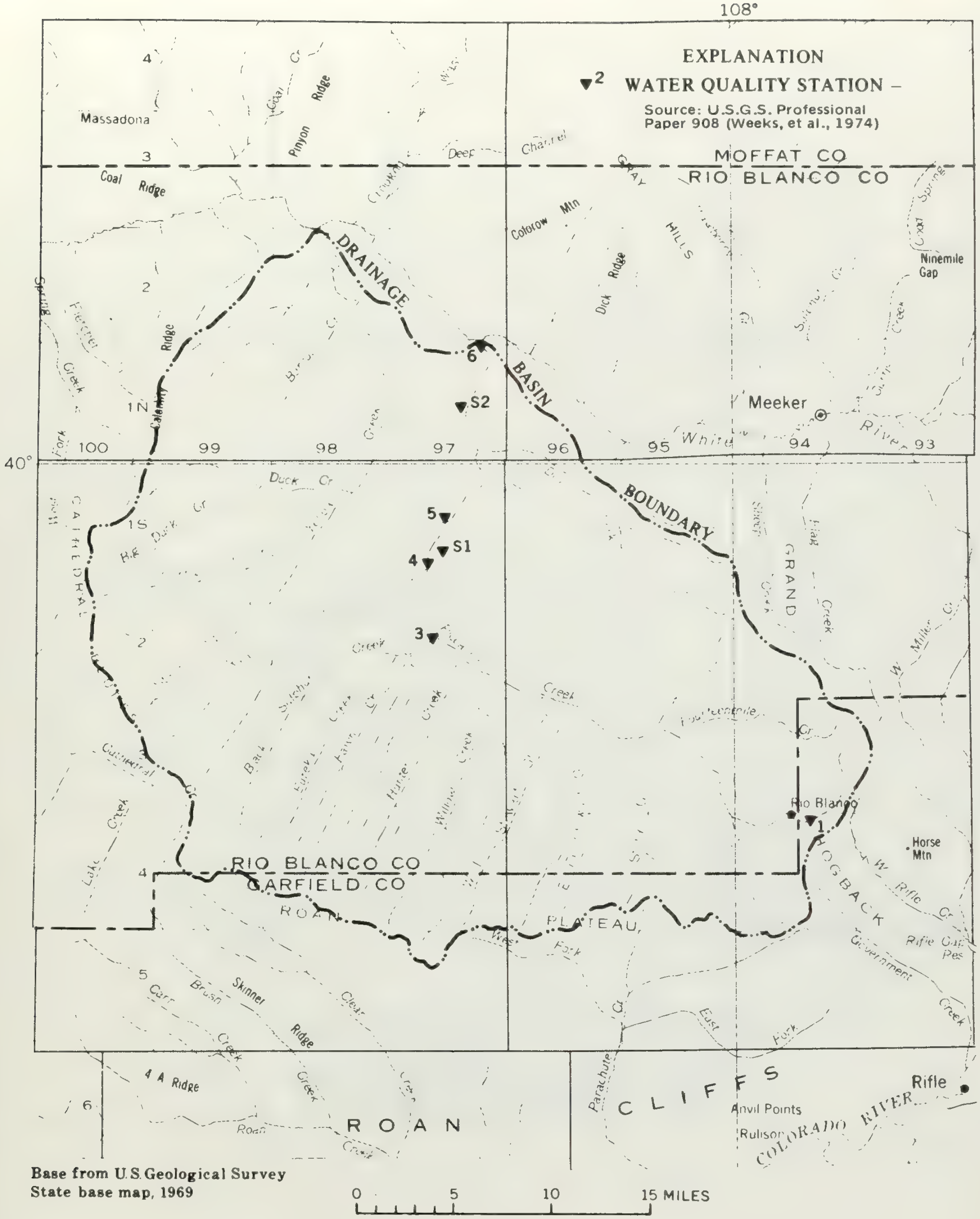


Figure IX–6 LOCATION OF U.S.G.S. WATER-QUALITY SAMPLING SITES ON STREAMS AND SELECTED SPRINGS

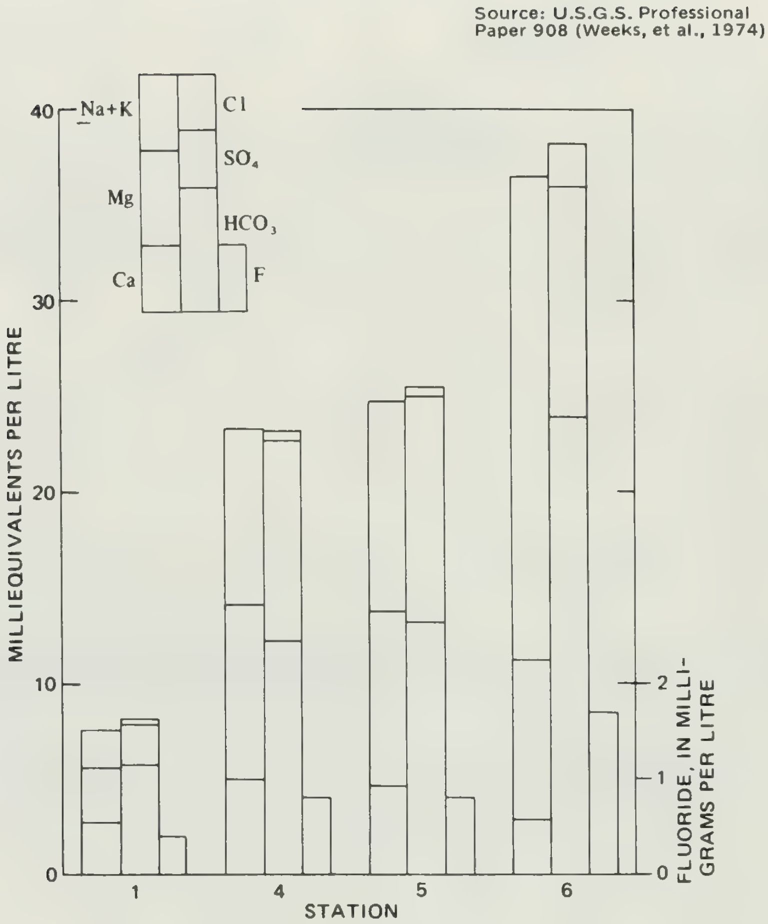
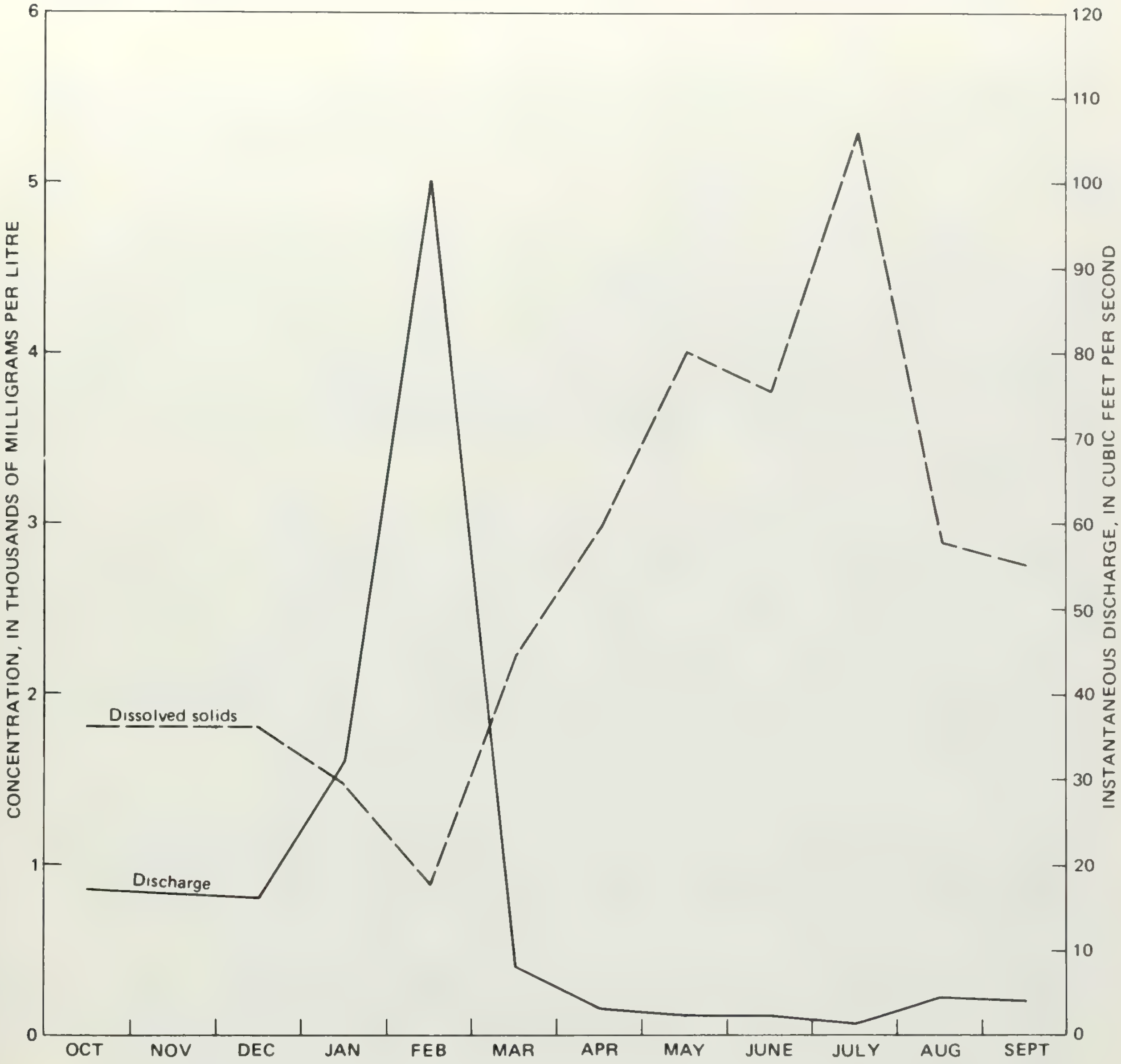


Figure IX–7 CHEMICAL COMPOSITION OF WATER OF PICEANCE CREEK



Source: U.S.G.S. Professional Paper 908 (Weeks, et al., 1974)

Figure IX–8 DISSOLVED-SOLIDS CONCENTRATION AND DISCHARGE MEASURED IN PICEANCE CREEK AT WHITE RIVER, 1972 WATER YEAR

the dissolved solids concentration decreased, because of dilution from snowmelt runoff. During the low-flow period, the concentration of dissolved solids increased because of the effects of irrigation return flows and ground-water discharge.

Numerous springs occur in the reaches of Piceance Creek between Ryan Gulch and the White River; several discharge water that has high concentrations of dissolved constituents. For example, the concentration of dissolved solids in the water from spring S1 (Figure IX-6) was found to be 2610 mg/l, and from spring S2, it was 22,100 mg/l. These samples were collected in June 1973. The water chemistry of both springs is affected by ground water which moves upward from the Parachute Creek member of the Green River formation, through the Uinta formation to the stream valley.

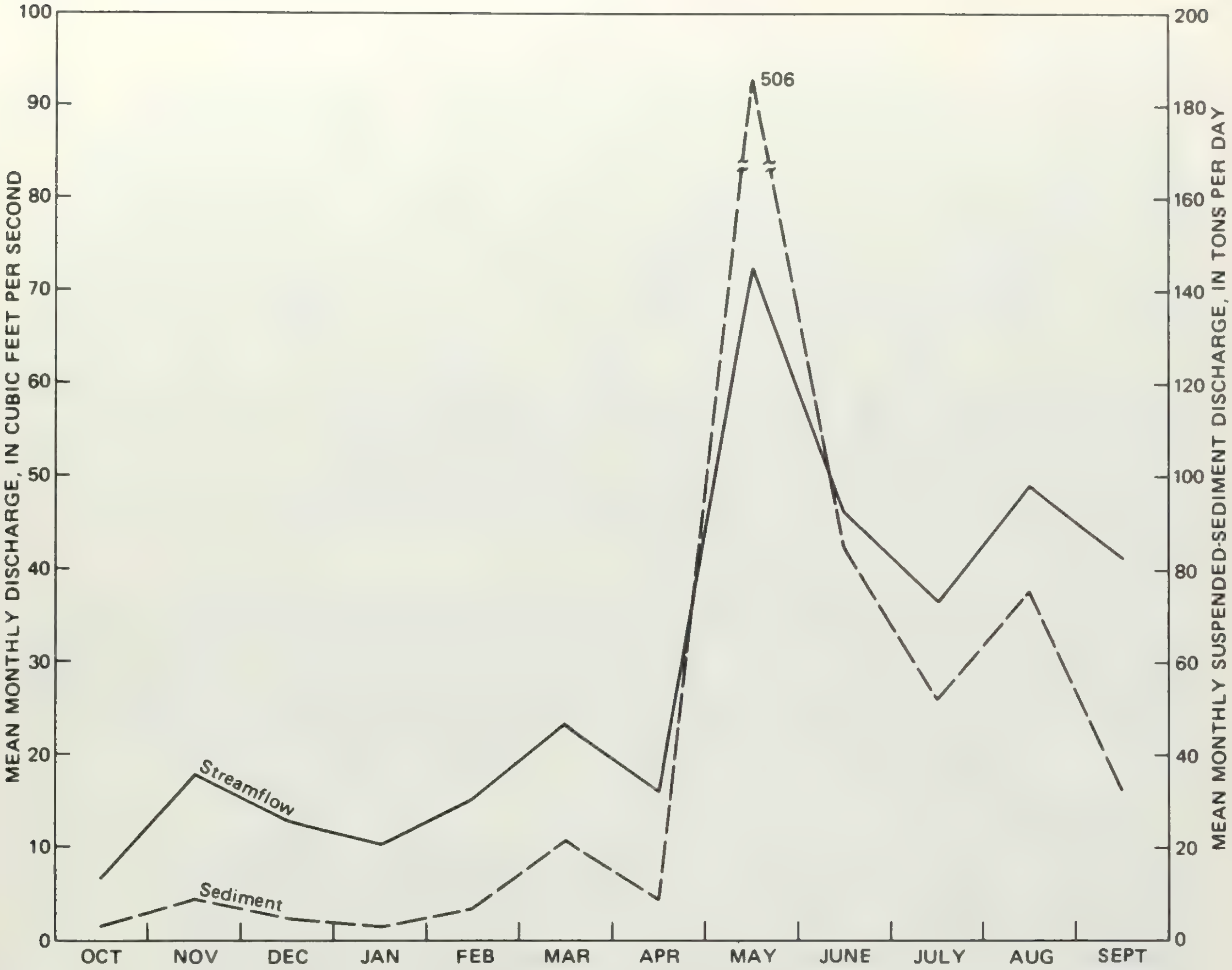
In the upper reaches of Piceance Creek, water-quality analyses indicate that the sulfate and dissolved solids concentrations exceed the limits of 250 mg/l and 500 mg/l, respectively, established in 1962 by the U. S. Public Health Service (USPHS) for public water supplies. Water in the lower reaches of these streams is unacceptable for domestic use because the fluoride concentrations exceed twice the optimum limit of 1.0 mg/l established by the USPHS (1962). Based on a dissolved solids limit of 5000 mg/l, the water in both creeks is acceptable for livestock watering during all but the lowest summer flows.

Suspended sediment discharge from Piceance Creek has been monitored at the gauge below Ryan Gulch (Figure IX-6, Station 4) since October 1972. Samples are automatically collected on a daily basis and during a rise in stage, the sampling frequency is increased. Analysis of the 1973 water-year data gives a total suspended sediment discharge for the year of about 25,000 tons, or about 0.03 acre-foot per square mile of drainage area. Figure IX-9 shows the mean monthly suspended sediment discharge for the 1973 water year and its relationship to mean monthly runoff. Maximum sediment discharges occurred during the high snowmelt runoff period in May, when the mean daily concentrations ranged from 1000 to 4000 mg/l. High sediment concentrations were also recorded for thunderstorms during August, with maximum concentrations exceeding 1000 mg/l.

Short-term studies conducted by the Colorado Department of Health showed that the dissolved oxygen content of Piceance Creek fluctuates on a diurnal basis. The Department concluded that the potential productivity of the water is high for algae, but is not high for fish life. Much of the substrate of the channel is silty and muddy and would not support a large trout population. Ranchers along the creek have periodically stocked the area for local benefit, so non-indigenous ranbow trout occur locally.

c. Willow Creek and Stewart Creek

In the vicinity of the Tract, two major perennial streams, Willow Creek and Stewart Creek, flow into Piceance Creek. Prior to the issuance of the Lease, no stream-gauging stations had been established on either of these streams.



Source: U.S.G.S. Professional Paper 908 (Weeks, et al., 1974)

Figure IX–9 SUSPENDED-SEDIMENT DISCHARGE AND RUNOFF FOR PICEANCE CREEK BELOW RYAN GULCH, 1973 WATER YEAR

Willow Creek borders on the Tract to the west (Figure IX-10). Several large springs south of the Tract provide significant flows to this creek (Figure IX-11); some of the water enters the alluvium along the creek bottom and is lost from the surface system. Willow Creek can be termed perennial throughout most of its length, from the head-water drainage area of East Fork Willow Creek to its mouth near the Tract. A major ephemeral tributary to Willow Creek is Scandard Gulch, which passes through the western portion of the Tract. It is generally dry.

The Stewart Gulch drainage system is located along the eastern edge of the Tract and also extends south of the Tract. Most of the channels are ephemeral and generally are dry. Perennial flows are found in the main stem of Stewart Gulch and West Fork Stewart Gulch. Flow in the main stem originates from a seepage area approximately one mile upstream from the junction with the West Fork.

Other drainages on the Tract include Sorghum Gulch, Cottonwood Gulch and the un-named gulch west of Cottonwood Gulch. All of these are ephemeral tributaries to Piceance Creek and are generally dry. Flow occurs only from snowmelt or from local thunderstorms. Very little data have been recorded because the flow events are very infrequent and of short duration.

2. Program Description

Terms of the Lease and Stipulations require that surface-water gauging stations be located on the major drainages of the Tract and, as defined by the AOSS, upstream and downstream of the leased lands. Records are kept of stream flow, water temperature, precipitation, and sediment; periodic analyses are made for selected chemical constituents.

Figure IX-10 shows the approximate locations and the official USGS designations of the 13 stream-gauging stations which have been installed on or near the Tract. The stations were constructed and are operated through a cooperative arrangement with the USGS and the Colorado River Water Conservation District. The USGS Water Resources Division sub-district office in Meeker, Colorado is operating and maintaining the stations as well as collecting and analyzing water samples for water quality. Table IX-1 summarizes the instrumentation and data obtained at each location. Table IX-2 lists the chemical analyses performed and the sampling frequency for the first year of baseline data. Nine of the stations are located on ephemeral or intermittent streams. The other four, however, are located on perennial drainages and are considered major gauging stations.

In accordance with the terms of the Lease, an inventory of natural surface features, such as seeps and springs, was conducted by field geologists. As depicted in Figure IX-11, no significant seeps or springs have been found on the Tract.

Although not required, water- quality samples were collected in September 1974 from each seep and spring identified near the Tract. Two locations were sampled again in the spring of 1975.

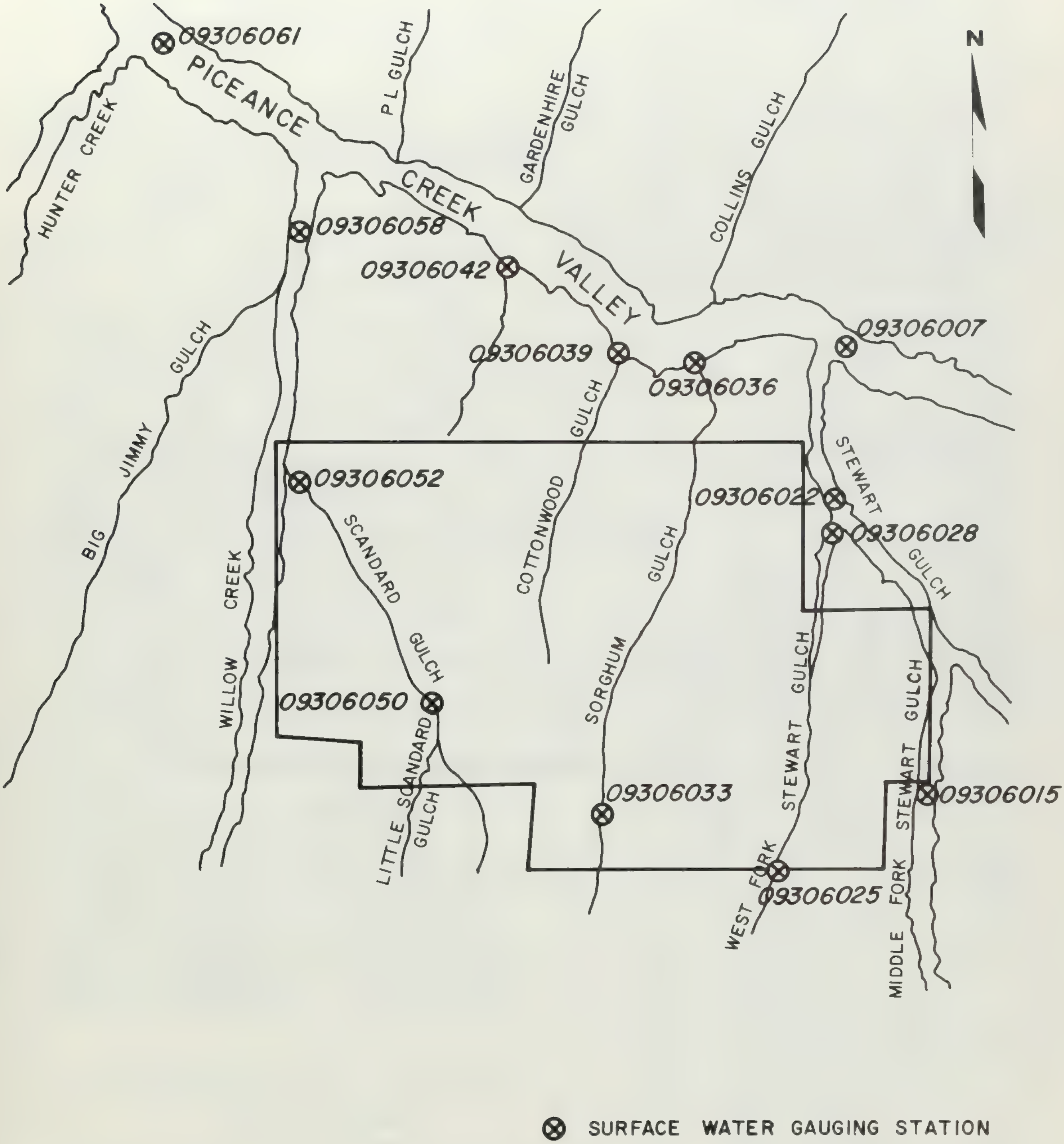


Figure IX–10 TRACT C-b SURFACE WATER GAUGING STATIONS

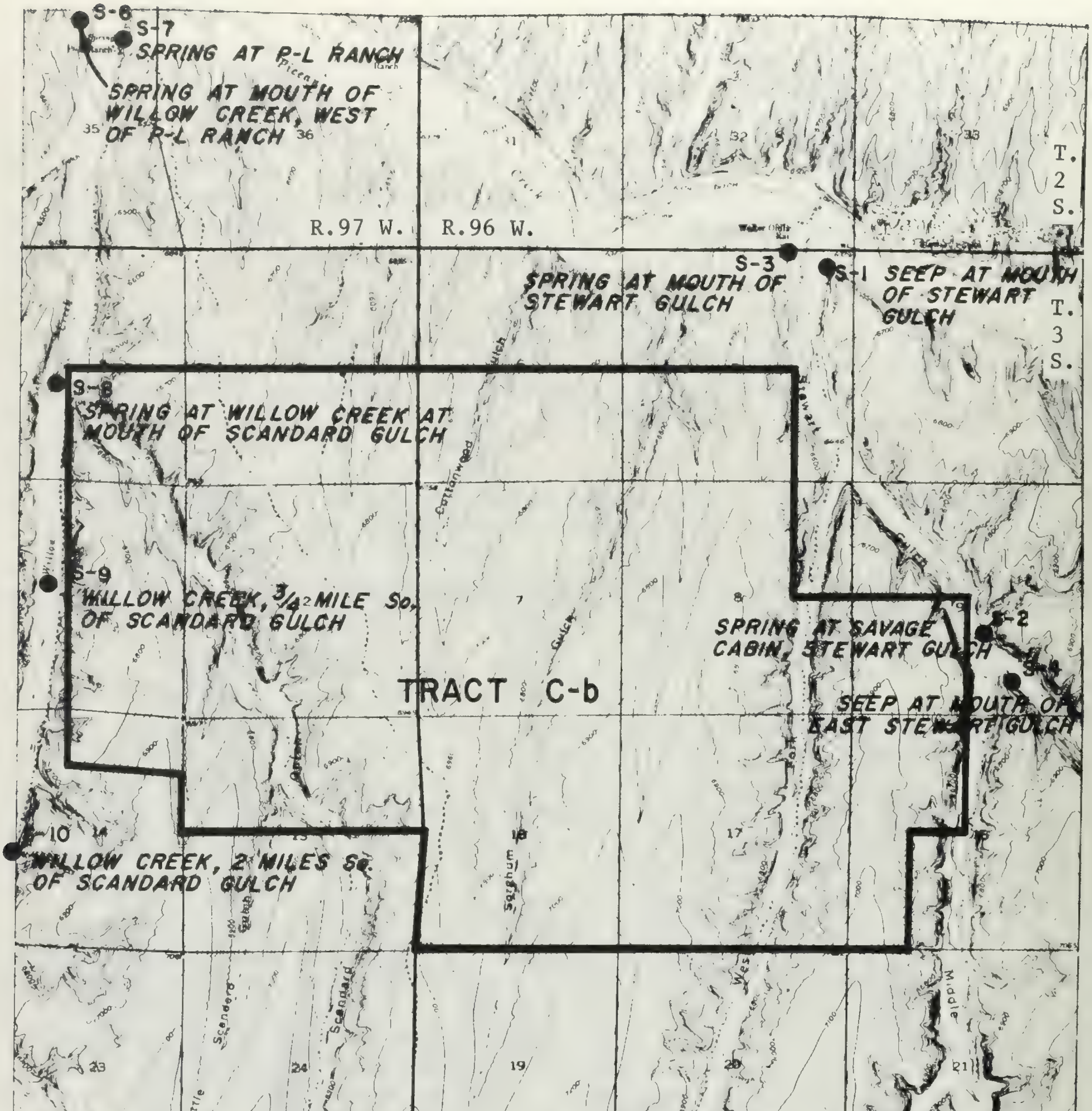


Figure IX–11 SPRINGS AND SEEPS

TRACT C-b AREA

Table IX–1 SURFACE WATER GAUGING STATIONS INSTRUMENTATION

	U.S.G.S. STATION NO.	U.S.G.S. STATION DESCRIPTION	Streamflow Recorders	Sediment Samplers	Temperature & Specific Conductivity Recorders	4-Parameter Recorders (+)	Turbidity Recorders
(*)	09306007	Piceance Creek below Rio Blanco	x	x		x	x
	09306015	Middle Fork Stewart Gulch nr Rio Blanco	x	x	x		x
	09306022	Stewart Gulch at West Fork nr Rio Blanco	x	x		x	
	09306025	West Fork Stewart Gulch nr Rio Blanco	x	x	x		
	09306028	West Fork Stewart Gulch at mouth near Rio Blanco	x	x	x		
	09306033	Sorghum Gulch nr Rio Blanco	x	x	x		
	09306036	Sorghum Gulch at mouth nr Rio Blanco	x	x	x		
	09306039	Cottonwood Gulch nr Rio Blanco	x	x	x		
	09306042	Piceance Creek Tributary nr Rio Blanco	x	x	x		
	09306050	Scandard Gulch nr Rio Blanco	x	x	x		
	09306052	Scandard Gulch at mouth nr Rio Blanco	x	x	x		
(*)	09306058	Willow Creek nr Rio Blanco	x	x		x	
(*)	09306061	Piceance Creek at Hunter Creek nr Rio Blanco	x	x		x	x

(*) – Major Gauging Station

(+) – Includes pH, Dissolved Oxygen, Temperature, and Specific Conductivity

Storage-type rain gauges are installed at Stations 09306015, 09306022, 09306050, and 09306058. In addition, precipitation data is being recorded at five air quality stations on or near the Tract.

Table IX-2 SURFACE WATER QUALITY ANALYTICAL PROGRAM REQUIREMENTS

	Semi-Monthly	Quarterly	Continuous	Continuous When Possible
1. Ammonia	x			
2. Aromatics, Polycyclic		x(M)		
3. Arsenic	x			
4. Barium	x			
5. Bicarbonate	x			
6. Boron	x			
7. Cadmium	x			
8. Calcium	x			
9. Carbonate	x			
10. Chloride	x			
11. Chromium	x			
12. COD		x(M)		
13. Coliform, Total & Fecal		x(M)		
14. Color	x			
15. Conductivity, Specific			x(M)	x(0)
16. Copper	x			
17. Cyanide	x			
18. Dissolved Oxygen	x		x(M)	
19. Fluoride	x			
20. Gross Alpha*		x(M)		
21. Gross Beta*		x(M)		
22. Iron	x			
23. Kjeldahl Nitrogen	x			
24. Lead	x			
25. Lithium	x			
26. Magnesium	x			
27. Manganese	x			
28. Mercury	x			
29. Nitrate	x			
30. Nitrite	x			
31. Odor	x			
32. Oil & Grease	x			
33. Ortho-Phosphate	x			
34. Pesticides		x(M)		
35. pH	x	x(M)		
36. Potassium	x			
37. Selenium	x			
38. Silica	x			
39. Sodium	x			
40. Solids, Dissolved	x			
41. Solids, Suspended (sediment)			x(M)	x(0)
42. Sulfate	x			
43. Sulfide	x			
44. Turbidity	x		x(PC)	
45. Zinc		x(M)		
46. Complete element scan for all trace elements		x(M)		
47. Total Organic Carbon (TOC) If TOC > 10 mg/liter, then Dissolved Organic Carbon Suspended Organic Carbon Phenols Sulfur (acid extraction) Nitrogen (base extraction)				
48. Stream Flow (discharge)			x(M)	x(0)
49. Water Temperature			x(M)	x(0)

* - Depending on count, thorium 230, radium 226, and natural uranium may be required.
(M) - Major Gauging Stations Only.
(0) - All Gauging Stations Except Major Stations.
(PC) - Piceance Creek Gauging Stations Only.

3. Results and Interpretations

a. Data Summaries

(1) Stream Gauging and Water Sampling Program

A record of surface water flow and quality on and near the Tract is being maintained through the semimonthly sampling program. Perennial streams are sampled regularly and ephemeral streams during flow events. Data are analyzed by the USGS and presented in the form of computer printouts. Summary tables have been prepared from these printouts and presented in the Summary Reports. Table IX-3 is a listing, by gauging station number, of samples for which results have been presented in the reports; it also indicates the report in which the data may be found.

Data for the four continuous recording stations, which measure flow, temperature, pH, dissolved oxygen and conductivity, are also available. Daily flow data for the perennial and ephemeral streams showed that there was negligible flow or no flow during the period of observation in most of the ephemeral streams. Data on sediment concentrations were collected on a daily basis for the four major gauging stations and for a few minor stations.

Hydrographs for the four major gauging stations are presented in Figures IX-12, IX-13, IX-14 and IX-15. These data represent the first full Standard Water Year (October 1974 through September 1975) of operation. Most of the stations actually began operation prior to October 1974 and data for that period may be found in the Summary Reports. Sediment concentrations for the corresponding stations and 1975 Standard Water Year are shown in Figures IX-16, IX-17, IX-18 and IX-19. The only two stations on emphemeral streams which recorded significant flows during the year were West Fork Stewart Gulch, USGS #025 and Cottonwood Gulch, USGS #039. (Only the last three digits of the station number are used in each case; e.g., 025 is USGS station numbered 09306025). Hydrographs for these stations are seen in Figures IX-20 and IX-21.

Examples of the continuous monitoring data for dissolved oxygen, temperature, pH, conductivity and turbidity are given in Figures IX-22, IX-23, IX-24, IX-25 and IX-26.

(2) Springs and Seeps

Elemental analyses were made of the water collected from the springs and seeps. Results are shown on Tables IX-4 and IX-5. The Colorado Division of Water Resources, in a cooperative program with the USGS has been collecting flow data from springs and seeps near the Tract. Table IX-6 gives the locations of springs studied by the Division and their correspondence to those shown in Figure IX-11. Figures IX-27 and IX-28 are hydrographs of the flow recorded by the Parshall flumes stationed near four of these springs.

Table IX–3 SURFACE WATER QUALITY
BASELINE DATA

U.S.G.S. Station #	Dates	Number of Samples	Tract C-b Quarterly Report #
(1) 09306007-Piceance Creek below Rio Blanco	4/28-9/27	16	1
	10/4-2/3	12	2
	2/19-4/2	4	3
	4/14-7/1	5	4
(2) 09306015-Middle Fork Stewart Gulch near Rio Blanco	None recorded		
(3) 09306022-Stewart Gulch at West Fork near Rio Blanco	9/12-10/23	3	1
	10/4-2/3	12	2
	2/19-4/2	4	3
	4/14-6/4	4	4
(4) 09306025-West Fork Stewart Gulch near Rio Blanco	5/3-10/23	15	1
	10/3-11/6	6	2
	11/20	1	3
	5/9-6/19	4	4
(5) 09306028-West Fork Stewart Gulch at mouth near Rio Blanco	None recorded		
(6) 09306033-Sorghum Gulch near Rio Blanco	None recorded		
(7) 09306036-Sorghum Gulch at mouth near Rio Blanco	None recorded		
(8) 09306039-Cottonwood Gulch near Rio Blanco	12/5	1	2
(9) 09306042-Piceance Creek Tributary near Rio Blanco	None recorded		
(10) 09306050-Scandard Gulch near Rio Blanco	6/21	1	1
	3/5	1	3
(11) 09306052-Scandard Gulch at mouth near Rio Blanco	3/5	1	3
(12) 09306058-Willow Creek near Rio Blanco	4/23-10/4	13	1
	10/4-2/3	12	2
	2/9-4/15	5	3
	5/7-5/22	2	4
(13) 09306061-Piceance Creek at Hunter Creek near Rio Blanco	4/23-10/23	15	1
	10/4-2/3	11	2
	2/19-4/3	4	3
	4/15-7/2	5	4

1975 WATER YEAR

Figure IX–12 HYDROGRAPH – PICEANCE CREEK BELOW RIO BLANCO (U.S.G.S. #09306007)

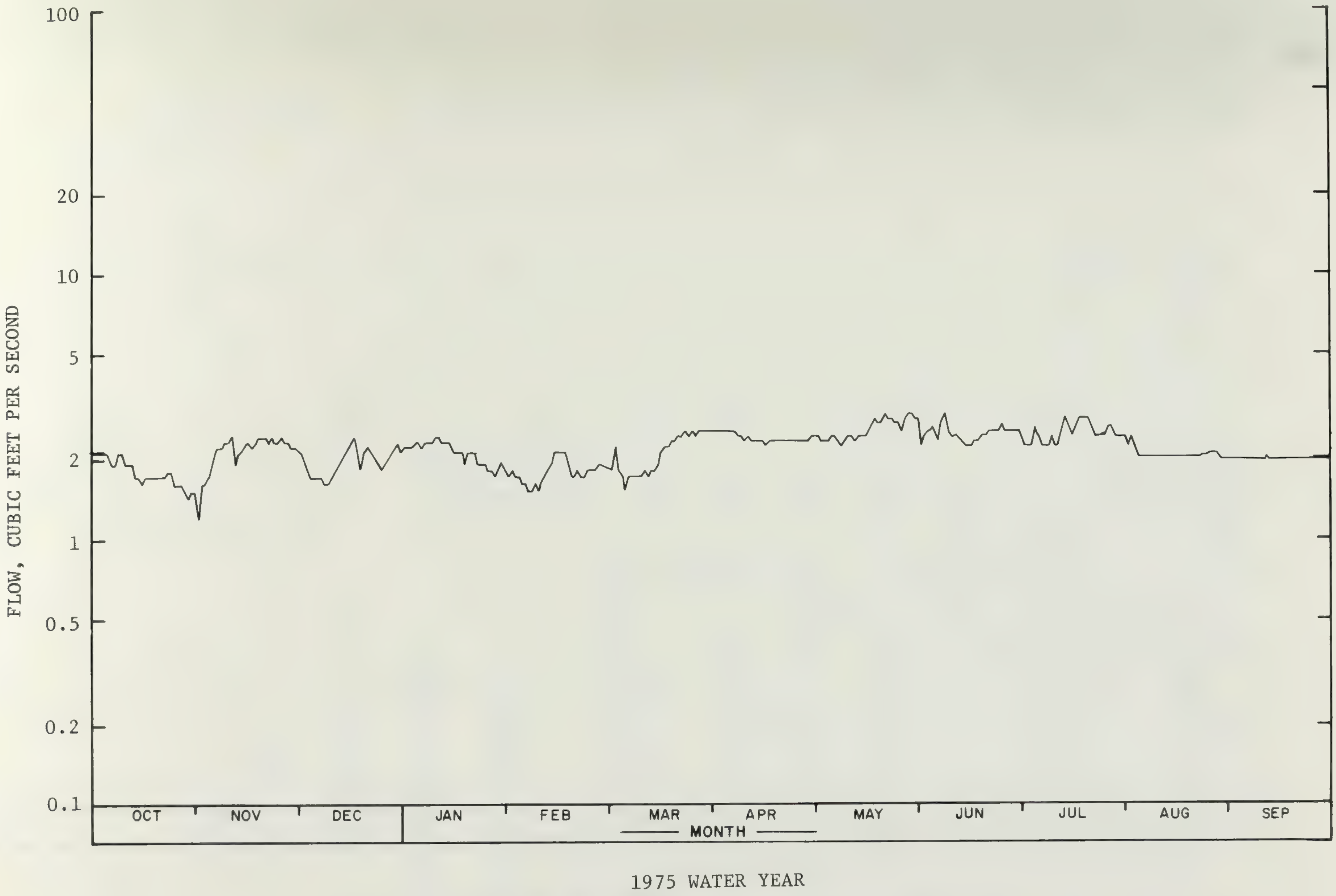


Figure IX–13 HYDROGRAPH – STEWART GULCH AT WEST FORK NEAR RIO BLANCO (U.S.G.S. #09306022)

1975 WATER YEAR

Figure IX–14 HYDROGRAPH – WILLOW CREEK NEAR RIO BLANCO (U.S.G.S. #09306058)

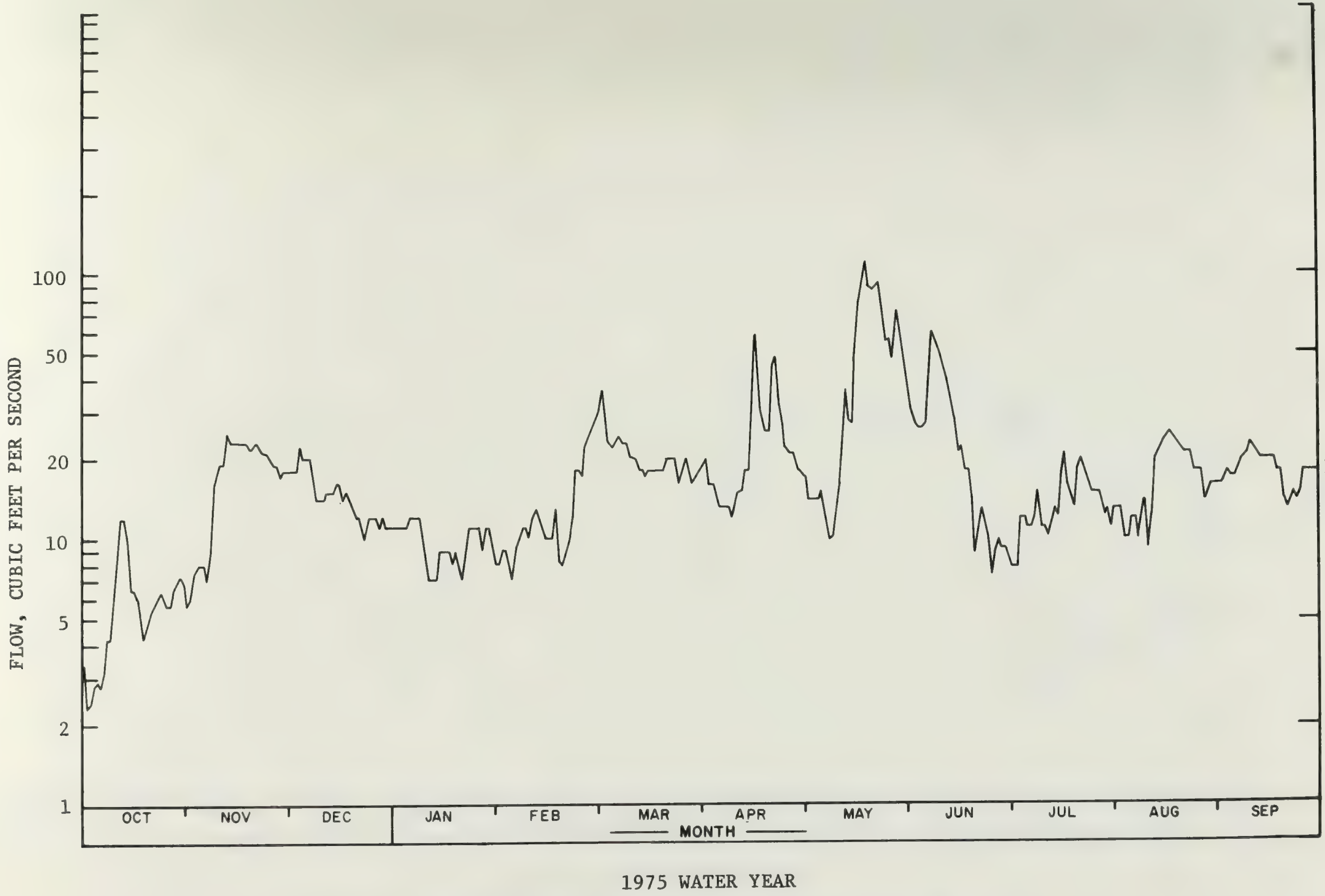


Figure IX–15 HYDROGRAPH – PICEANCE CREEK ABOVE HUNTER CREEK NEAR RIO BLANCO (U.S.G.S. #09306061)

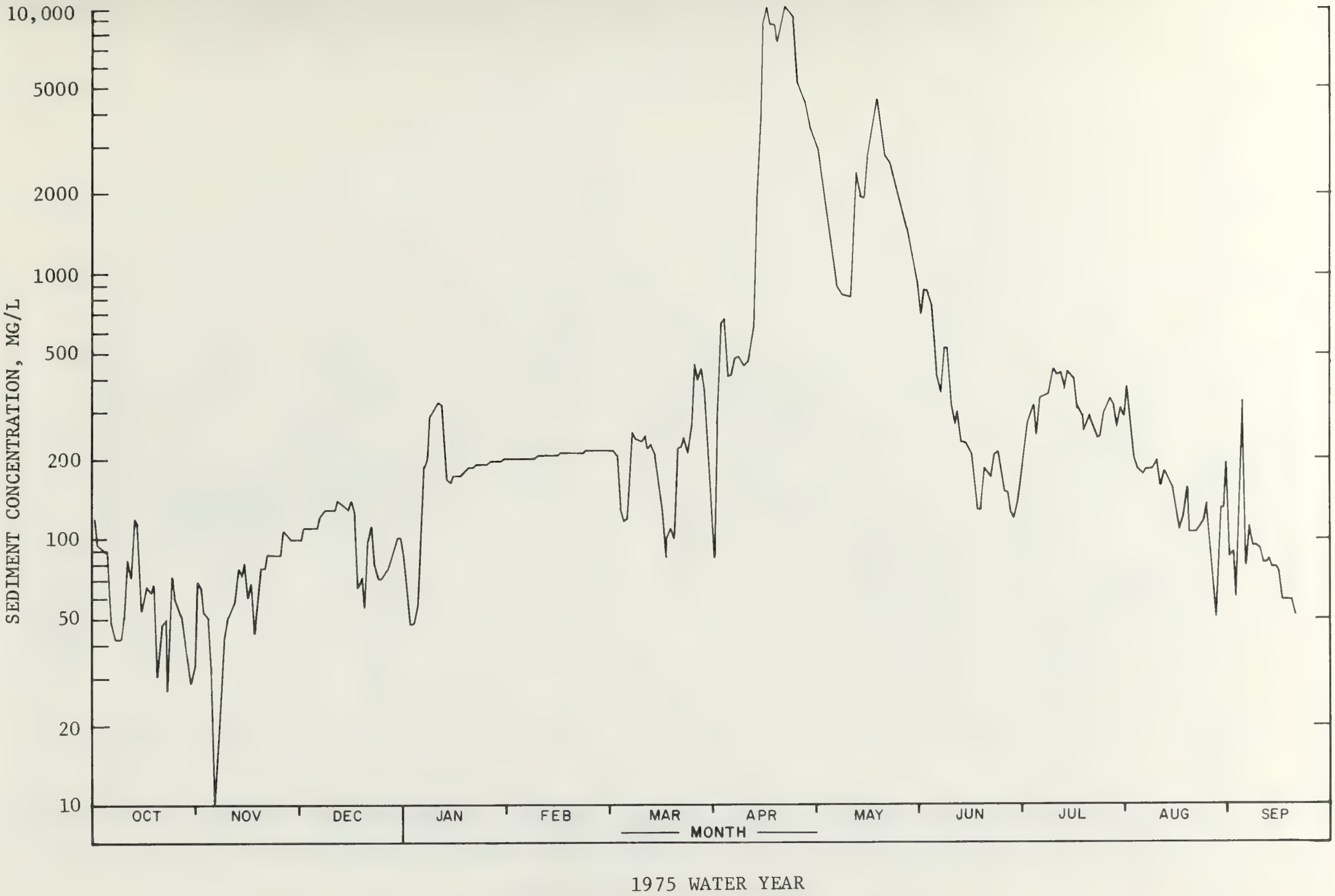


Figure IX–16 SEDIMENT CONCENTRATION – PICEANCE CREEK BELOW RIO BLANCO (U.S.G.S. #09306007)

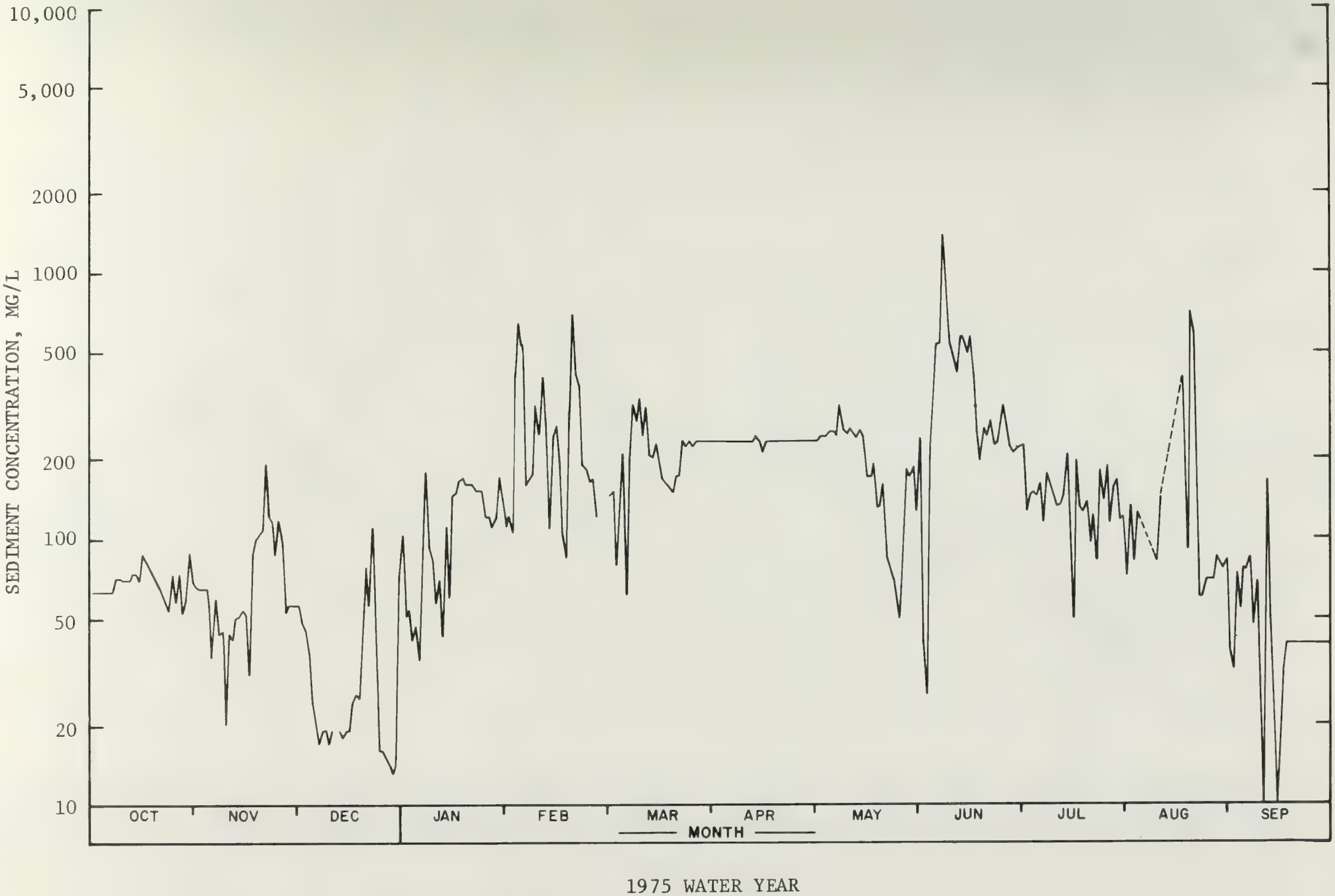


Figure IX–17 SEDIMENT CONCENTRATION – STEWART GULCH AT WEST FORK NEAR RIO BLANCO (U.S.G.S. #09306022)

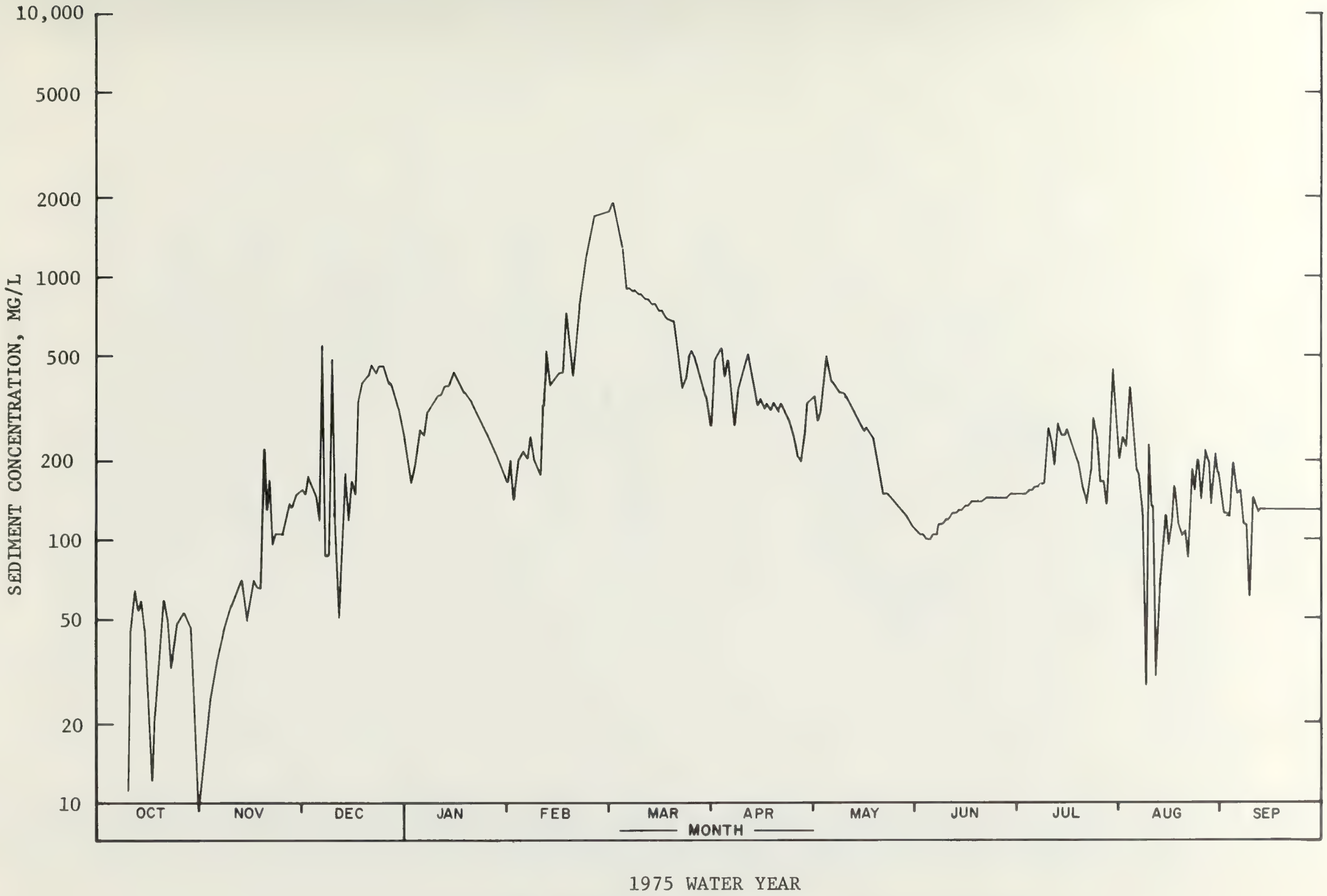
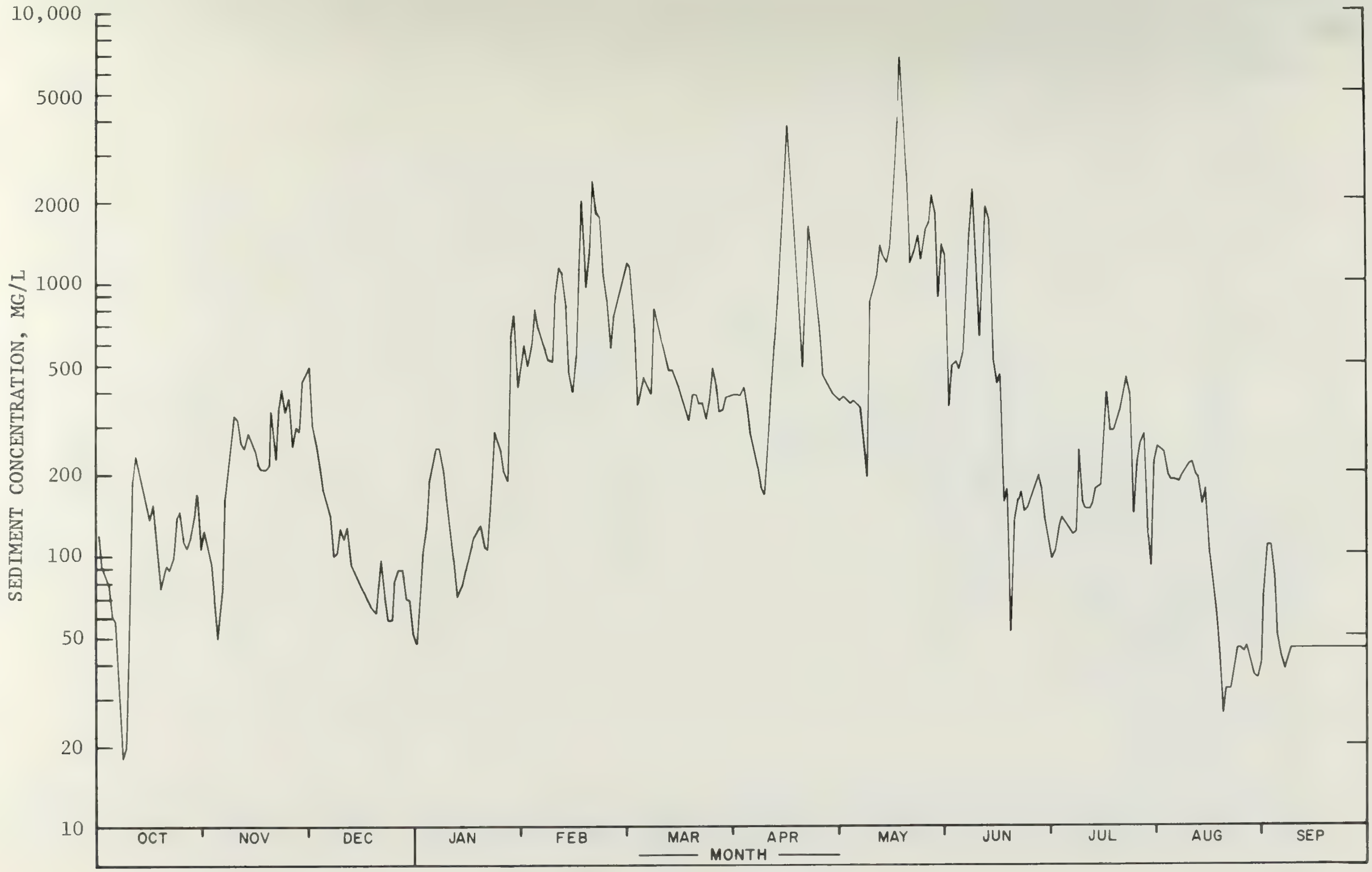
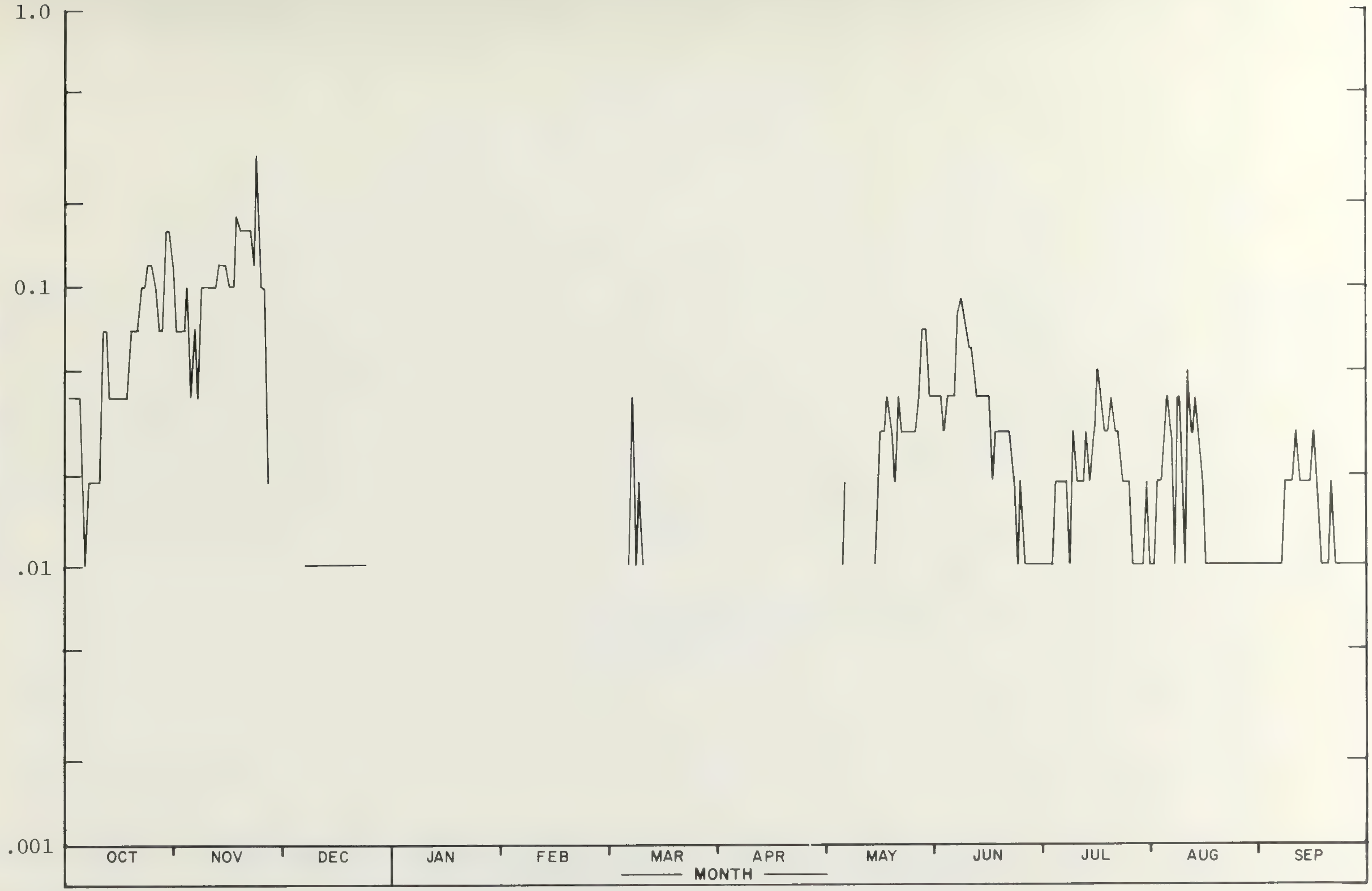


Figure IX–18 SEDIMENT CONCENTRATION – WILLOW CREEK NEAR RIO BLANCO (U.S.G.S. #09306058)



1975 WATER YEAR

Figure IX–19 SEDIMENT CONCENTRATION – PICEANCE CREEK ABOVE HUNTER CREEK NEAR RIO BLANCO (U.S.G.S. #09306061)



1975 WATER YEAR

Figure IX–20 HYDROGRAPH – WEST FORK STEWART GULCH NEAR RIO BLANCO (U.S.G.S. #09306025)

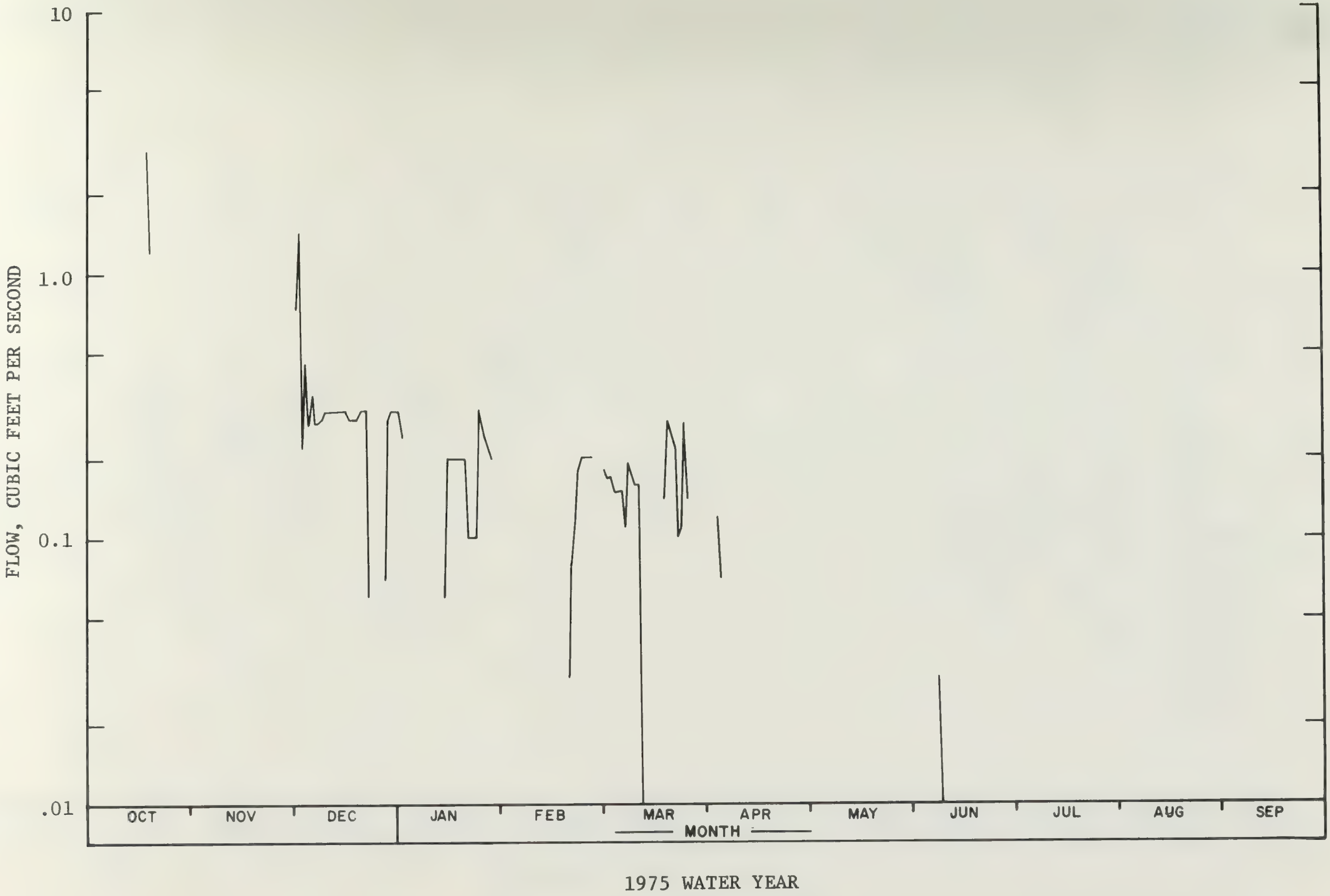


Figure IX–21 HYDROGRAPH – COTTONWOOD GULCH NEAR RIO BLANCO (U.S.G.S. #09306039)

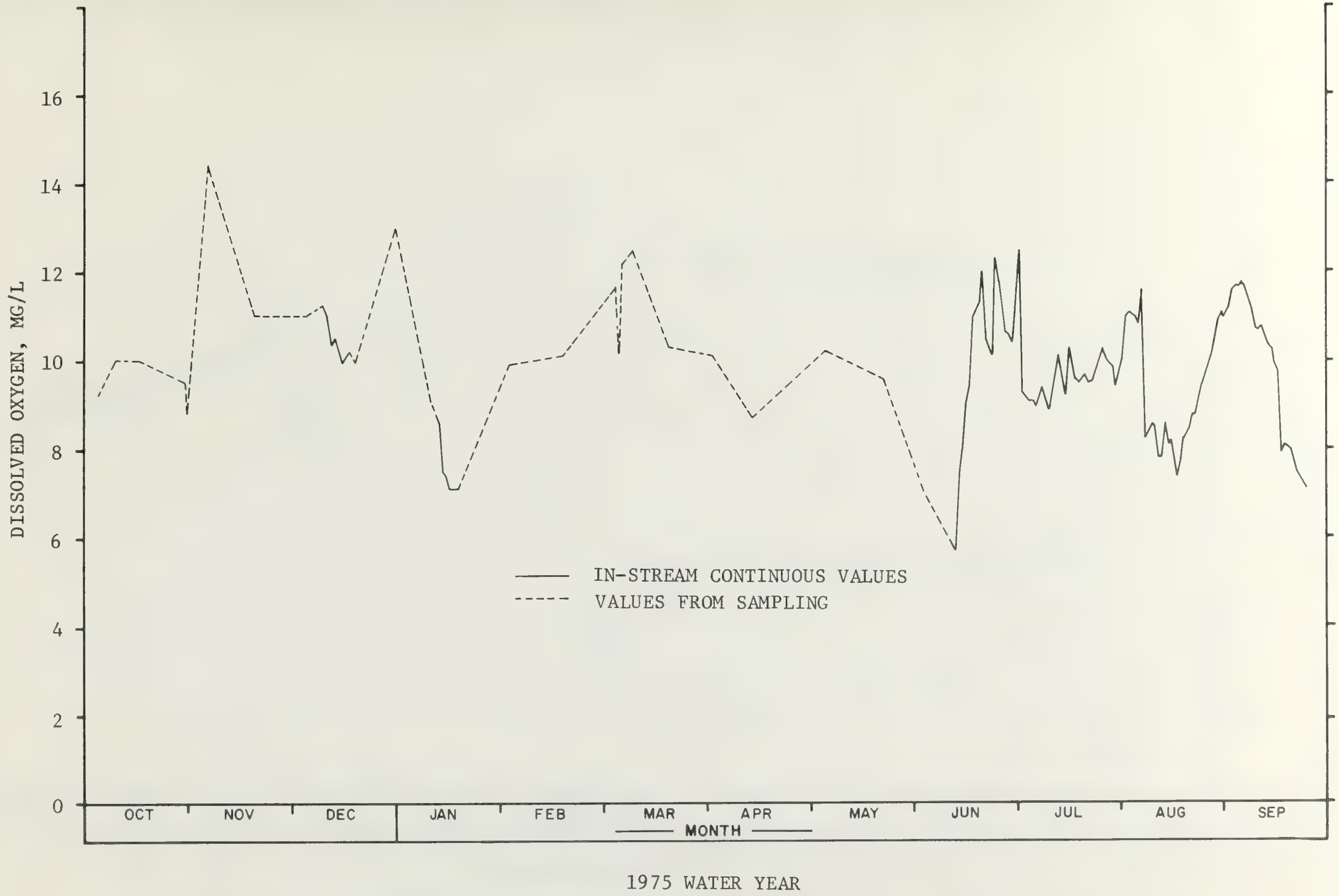


Figure IX—22 DISSOLVED OXYGEN – PICEANCE CREEK BELOW RIO BLANCO (U.S.G.S. #09306007)

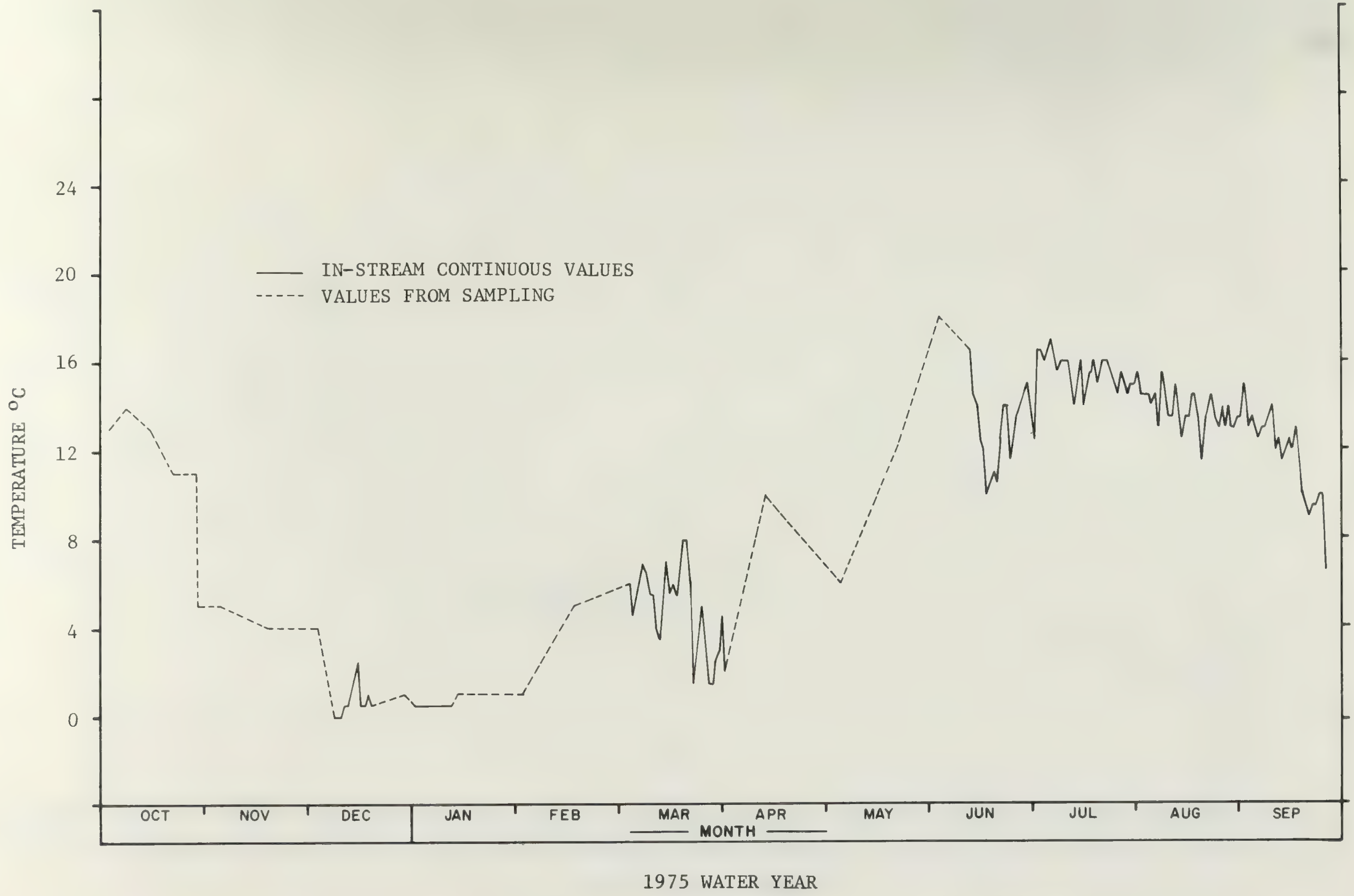


Figure IX–23 STREAM TEMPERATURE – PICEANCE CREEK BELOW RIO BLANCO (U.S.G.S. #09306007)

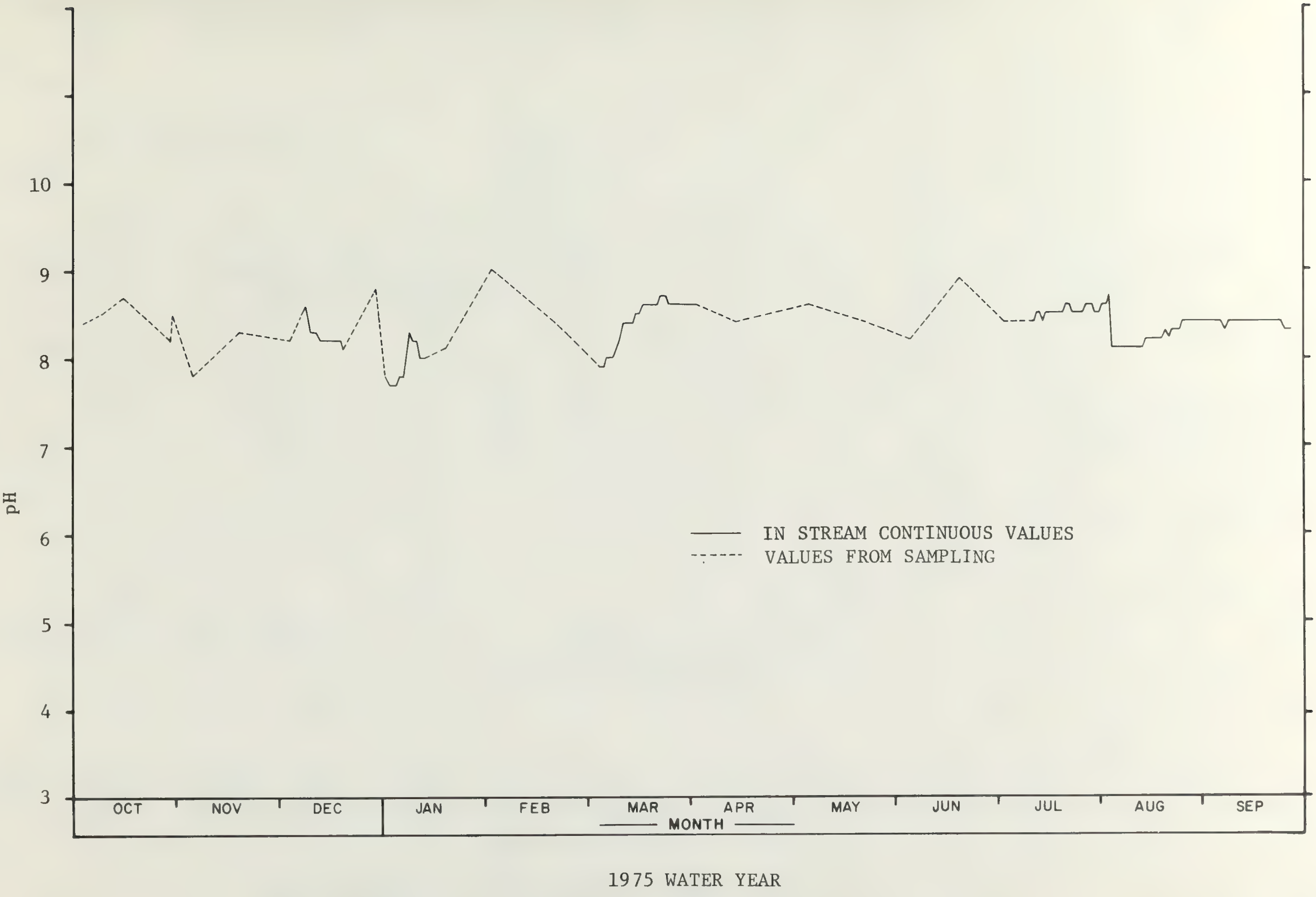


Figure IX–24 pH – PICEANCE CREEK BELOW RIO BLANCO (U.S.G.S. #09306007)

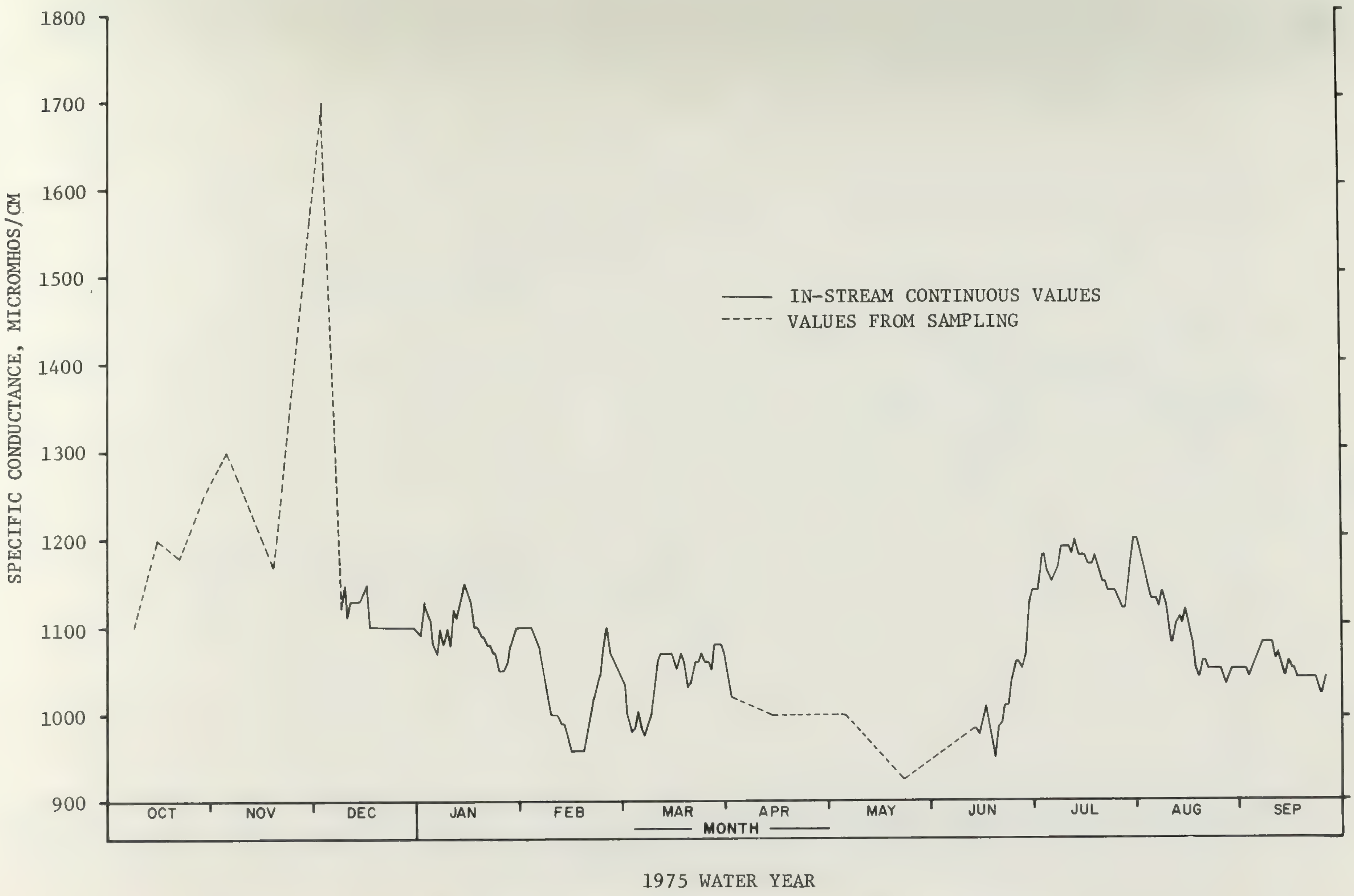


Figure IX–25 SPECIFIC CONDUCTANCE – PICEANCE CREEK BELOW RIO BLANCO (U.S.G.S. #09306007)

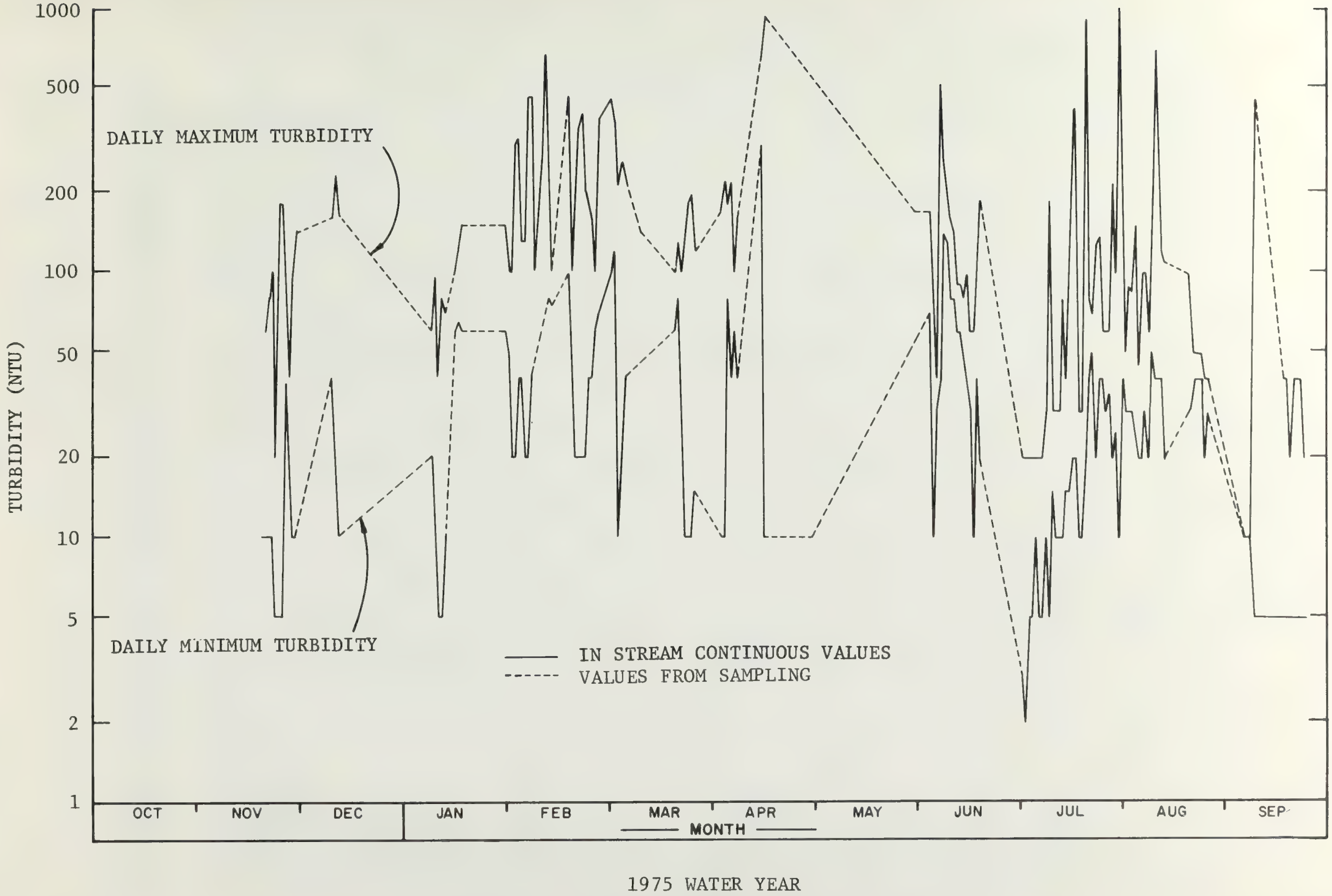


Figure IX–26 MAXIMUM AND MINIMUM TURBIDITY – PICEANCE CREEK ABOVE HUNTER CREEK NEAR RIO BLANCO (U.S.G.S. #09306061)

Table IX–4 WATER QUALITY ANALYSIS

SPRINGS AND SEEPS (a)

(Unless stated otherwise, all units are mg/1)

Location: (See Figure IX–11 and footnote)

Element Measured	S–1	S–2	S–3	S–4	S–6	S–7	S–8	S–9	S–10
1. Aluminum	.06	.1	.3	0.1	1.3	2.3	.2	.2	6.1
2. Ammonia	.1	<.1	<.1	<.1	<.1	<.1	0.1	0.1	0.1
3. Arsenic	.003	.004	.003		.03	.004		.002	.002
4. Barium	.02	.05	.01	.05	.03	0.01	.06	.05	.05
5. Beryllium	<.005	.002	<.006	.001	<.007	<.007	<.007	<.003	<.001
6. Bicarbonate	520	495	520	480	560	520	606	516	540
7. Bismuth	<.005	<.006	<.006	<.007	<.007	<.007	<.007	<.003	<.001
8. Boron	1.4	1.2	1.1	1.2	1.6	1.6	0.2	0.4	0.6
9. Cadmium	<.005	<.006	<.006	<.007	<.007	<.007	<.007	<.003	<.001
10. Calcium	100	82	92	66	102	116	143	130	161
11. Carbonate	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1
12. Cerium	.005	<.006	<.006	.005	<.007	<.007	.005	.002	.002
13. Chloride	4.2	4.8	4.8	3.5	4.	4.	4.0	4.0	0.8
14. Chrome, Hexavalent	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01
15. Cobalt	0.002	<.006	.004	0.03	0.01	0.002	.02	.05	.002
16. Conductivity, Specific	1380	1145	1250	1100	1250	1260	1280	1180	1180
17. Copper	.04	.04	.03	.2	.05	.03	.2	.1	.03
18. Fluoride	.9	.6	.7	.6	2.1	1.5	1.7	1.5	1.4
19. Gallium	<.005	<.006	<.006	.006	0.005	0.006	<.007	<.003	<.001
20. Hardness, Total	484	536	380	548	512	512	576	512	516
21. Hydroxide	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1
22. Iron	1.8	.5	4.0	7.8	.8	.7	.14	.84	.47
23. Lead	<.005	.01	.02	.04	.03	.03	<.007	<.003	.02
24. Lithium	.05		.03	.3	.4	.1	.1	.5	.2
25. Magnesium	57	81	37	93	63	54	53	46	28
26. Manganese	.2	.02	.04	1.4	.03	.01	.1	.05	.06
27. Mercury	.001	.001	.002	.001	.0017	.0003	.0001	.0001	.0014
28. Molybdenum	<.005	<.006	<.006	.013	0.01	<.007	.06	.2	.02
29. Nickel	0.02	.004	.01	.08	0.01	0.009	.01	.02	.005
30. Nitrate	8.1	5.4	5.6	6.0	2.7	2.9	1.1	1.7	.1
31. pH	7.9	8.0	7.6	7.8	8.2	8.1	7.9	8.1	7.9
32. Phosphate, Total	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1
33. Potassium									
34. Selenium	.005	<.006	<.006	<.007	<.007	<.007	<.007	<.003	<.001
35. Silica	12	13	13	13	15	16	13	14	13
36. Silver	<.005	<.006	<.006	<.007	<.007	<.007	<.007	<.003	<.001
37. Sodium	200	110	195	90	163	147	138	152	125
38. Solids, Dissolved	1078.	875	972	805	988	967	995	948	910
39. Strontium	1	3	2	4	5	2	3	1	1
40. Sulfate	440	335	370	290	360	375	350	350	310
41. Titanium	0.1	.06	.08	0.1	0.3	0.2	0.2	0.2	0.2
42. Vanadium	0.004	.005	.002	.009	0.004	0.004	.003	.005	.002
43. Yttrium	<.005	.002	<.006	.003	<.007	<.007	<.007	<.003	<.001
44. Zinc	0.04	.1	.3	.1	0.4	.08	.05	.2	.2
45. Zirconium	<.005	<.006	<.006	<.007	<.007	<.007	<.007	<.003	<.001
46. Radioactivity									
Gross Alpha (pcl)	2.8	2.1	3.4	4	3.3	1.6	4.2	4.7	1.3
Radium 226							0.3	0	
Gross Beta (pcl)	0	0	0	0	0	0	0	0	0
47. Total Organic Carbon (TOC)	6	3	4	3	3	6	3	3	6

1. Seep @ Mouth Stewart Creek. 2. East Stewart Gulch Stream from Seeps @ Mouth. 3. Spring at Mouth of Stewart Gulch. 4. Spring at Savage Cabin Stewart Gulch. 6. Spring @ Mouth of Willow Creek West of PL Ranch. 7. Spring @ PL Ranch. 8. Spring @ Willow Creek at Mouth of Scandard. 9. Willow Creek 3/4 mile past Scandard. 10. Willow Creek 2 miles past Scandard.

(a) all samples taken during week of September 30, 1974

Table IX–5 WATER QUALITY ANALYSIS
SPRINGS AND SEEPS
MAY 1975

Location At Which Sample Taken (See footnote)

ELEMENT MEASURED–UNITS(mg/1) UNLESS NOTED	a	b			
1. Aluminum		6.1			
2. Ammonia (Nitrogen)		.1			
3. Arsenic		< .01			
4. Barium		< 1.0			
5. Beryllium					
6. Bicarbonate	650	540			
7. Bismuth					
8. Boron		.6			
9. Cadmium		< .01			
10. Calcium	48	161			
11. Carbonate	< .1	< .1			
12. Cerium					
13. Chloride	17	.8			
14. Chrome, Hexavalent		< .01			
15. Cobalt					
16. Conductivity, Specific (μ℧ /cc)					
17. Copper		< .1			
18. Fluoride	.2	1.4			
19. Gallium					
20. Hardness (mg/1 $CaCO_3$)	440	516			
21. Hydroxide		< .1			
22. Iron	< .05	< .47			
23. Lead		< .05			
24. Lithium		< .5			
25. Magnesium	78	28			
26. Manganese		< .05			
27. Mercury		< .01			
28. Molybdenum					
29. Nickel					
30. Nitrate	.5	.1			
31. pH	7.4				
32. Phosphate, Total	< .1	< .1			
33. Potassium					
34. Selenium		< .01			
35. Silica	21	13			
36. Sodium	240	125			
37. Solids, Dissolved	1090	910			
38. Strontium					
39. Sulfate	370	310			
40. Titanium					
41. Vanadium					
42. Yttrium					
43. Zinc		< .5			
44. Zirconium					
45. Radioactivity					
Gross Alpha (pcl)					
Radium 226*					
Gross Beta (pcl)					
Thorium 230**					
Uranium**					
46. Total Organic Carbon (TOC)					
If TOC 10 mg/1 then measure					
Dissolved Organic Carbon					
Suspended Organic Carbon					
Phenols					
Sulfate, Acid Extraction					
Nitrogen, Base Extraction					
Polycyclic Aromatics					

* Required if gross alpha is greater than 4 picocuries per liter (pcl).
** Required if gross beta is greater than 100 picocuries per liter (pcl).

a Spring floor of Piceance Creek Valley North of SG-19.
b Willow Creek 2 miles past Scandard Gulch.

Table IX–6 LOCATIONS OF SPRINGS AND SEEPS

Identification of Water Resources Division Springs

Designation	I.D.#	Location	Corresponding Identification in Figure IX–4
S–l and S–1–A *	1081 1082	Lat 039° 49' 30" Lon 108° 11' 07"	S1, S3 and S5
CER–6**	1063	Lat 039° 48' 25" Lon 108° 10' 34"	S2 and S4
W–1	1078	Lat 039° 50' 20" Lon 108° 14' 35"	S6 and S7
W–2	1110	Lat 039° 47' 36" Lon 108° 14' 59"	S9
W–3	1079	Lat 039° 47' 17" Lon 108° 15' 03"	S10

* These springs are close by. Single flume measures the discharge from both the springs.

** This is a measuring site. Measure flow from two upstream springs.

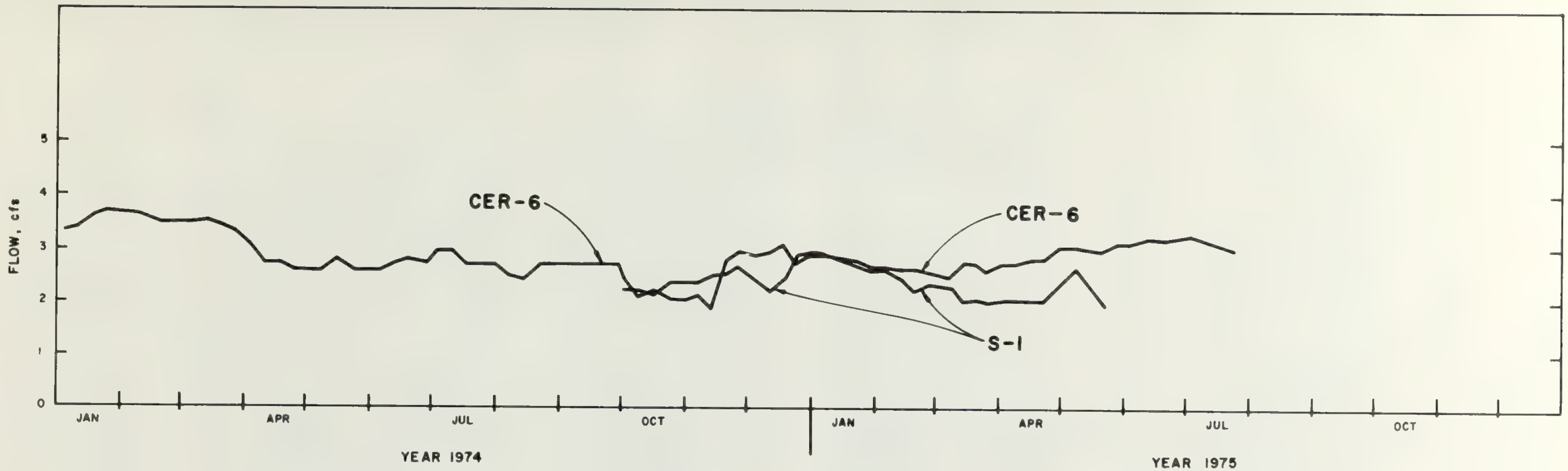


Figure IX–27 HYDROGRAPH – SPRINGS S-1 AND CER-6

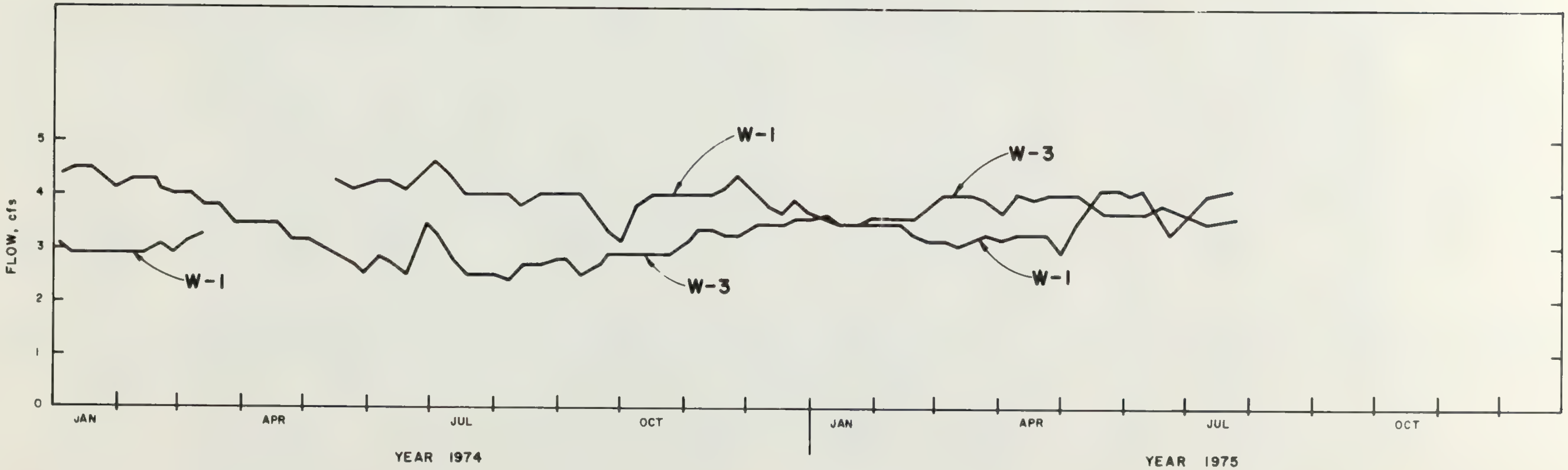


Figure IX–28 HYDROGRAPH – SPRINGS W-1 AND W-3

b. Interpretations

(1) Stream Discharge and Water Quality

The hydrograph patterns of Piceance Creek for upstream and downstream continuous gauging stations are in general agreement (Figures IX-12 and IX-15). The flow at the downstream gauging station generally is higher than at the upstream gauging station because of the influx from tributaries. At low flow levels, the hydrograph patterns fluctuate largely because of loss of water in seepage and evaporation. At higher flow levels, these components form a minor part of total flow.

Continuous temperature measurements show a marked diurnal pattern (Figure IX-29) with peaks in the afternoon and lows in the morning, as might be expected in a shallow stream.

Figure IX-30 shows the major ionic constituents and the water hardness as determined at the five gauging stations where the stream flow is more or less perennial. All the waters have quite high TDS levels with the tributaries exhibiting higher TDS than the main stream. Magnesium and sodium are the dominant cations; sodium is dominant on the main stream as shown at station 007 and 061, and magnesium is the dominant cation on the tributaries of Stewart Gulch and Willow Creek. Bicarbonate is the dominant anion at all locations, except the West Fork Stewart Gulch, where sulfate dominates.

Maximum, minimum and median concentrations of selected stream water constituents for the five gauging stations are presented on Tables IX-7 through IX-11. The upstream station, 007, along Piceance Creek shows the lowest concentration of TDS and the lowest concentrations of most constituents. The median TDS at this location is 718 mg/l. Higher concentration of TDS in the tributary streams, which reach a maximum of more than 1450 mg/l along Stewart Gulch, contribute to the downstream increase in the TDS content of Piceance Creek. Below the Tract, the median TDS content is more than 900 mg/l.

To show the relationships between flow rate and TDS content, several chronological plots of ion concentration were made and compared to a plot of discharge (as determined manually at the time of sampling) over the same time period (Figures IX-31 through IX-37). Stations 007 and 061 on Piceance Creek showed the same general pattern. During the summer, the discharge at the downstream station, 061, is sometimes lower than that at the upstream station. This is a phenomenon of the growing season and the withdrawal of water for irrigation. Except for a few peak recordings, after mid-July the flows at stations 007 and 061 were fairly equal until mid-November. From then to mid-April the flow at the downstream station, 061, exceeded that at the upstream station, 007.

Little change was seen in the concentrations of the various constituents as a function of flow during 1975. The data for 1974 exhibited

STATION 007
PICEANCE CREEK BELOW RIO BLANCO

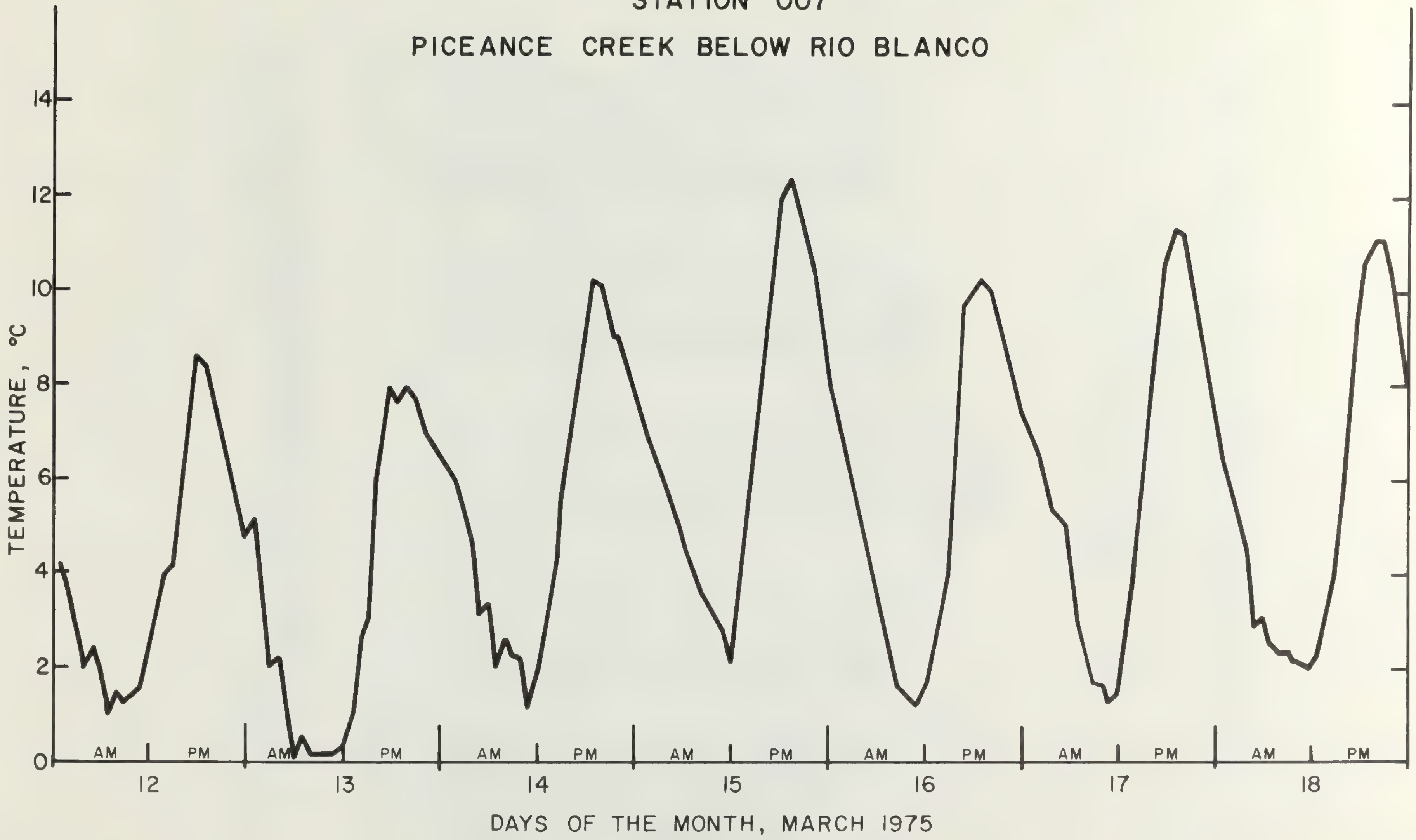


Figure IX–29 DIURNAL TEMPERATURE VARIATIONS

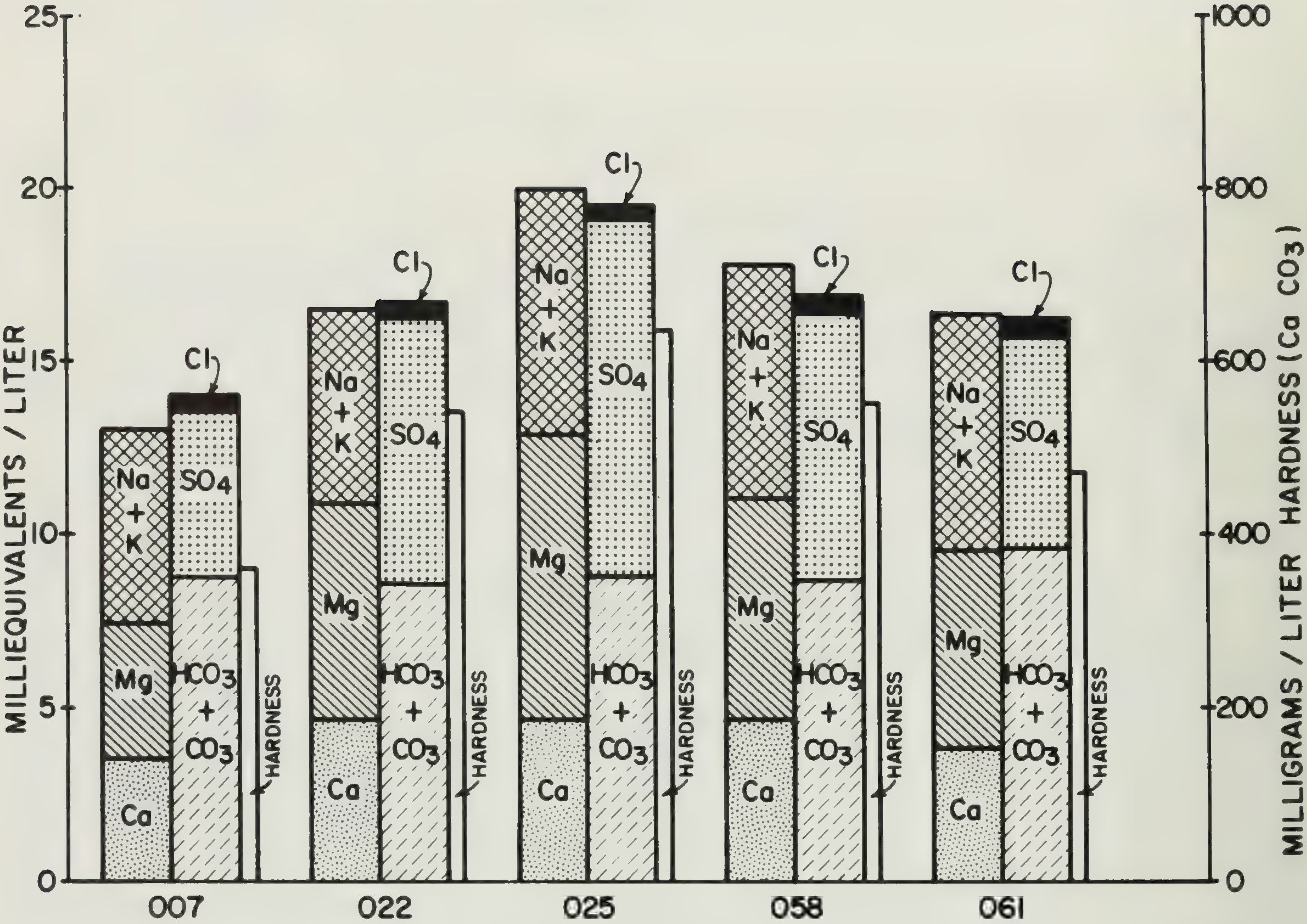


Figure IX–30 DISTRIBUTION OF MAJOR IONS
SURFACE WATER GAUGING STATIONS, TRACT C-b AREA

Table IX–7 MINIMUM-MAXIMUM AND MEDIAN CONCENTRATIONS FOR SELECTED WATER QUALITY CONSTITUENTS

U.S.G.S. NO. 09306007
PICEANCE CREEK BELOW RIO BLANCO, CO.
April 23, 1974 to April 2, 1975
Elevation – 6366 ft. above MSL

Total No. of Samples		Minimum	Median	Maximum
34	Temperature (°C)	0.0	10.0	22.0
31	Discharge (CFS)	2.9	9.5	34
9	Turbidity (JTU) Dec. 1974 - April 1975	6	20	130
33	Specific Conductivity (micromhos)	912	1160	1270
30	Dissolved Oxygen (mg/1)	7.0	10.2	13.0
33	pH	6.9	8.2	9.0
33	Alkalinity (mg/1)	358	445	506
33	Bicarbonate (mg/1)	436	542	617
23	Carbonate (mg/1)	0	0	32
9	Nitrate (NO_3) (mg/1) Dec. 1974 - April 1975	0.44	1.4	2.5
34	Orthophosphate (mg/1)	0.00	0.06	1.1
34	Calcium (mg/1)	51	70	77
34	Magnesium (mg/1)	38	47	57
34	Sodium (mg/1)	88	130	160
34	Potassium (mg/1)	2.4	3.4	19
34	Chloride (mg/1)	9.7	16	24
34	Sulfate (mg/1)	130	170	200
34	Fluoride (mg/1)	0.2	1.0	1.3
34	Silica (mg/1)	3.4	16	18
34	Iron (μg/1)	10	50	390
33	Manganese (μg/1)	10	110	230
33	Dissolved Solids (mg/1)	578	718	829

Table IX–8 MINIMUM-MAXIMUM AND MEDIAN CONCENTRATIONS FOR SELECTED WATER QUALITY CONSTITUENTS

U.S.G.S. NO. 09306022
STEWART GULCH ab WEST FORK nr RIO BLANCO, CO.
September 12, 1974 to April 2, 1975

Total No. of Samples		Minimum	Median	Maximum
19	Temperature (°C)	1.0	8.0	12.0
17	Discharge (CFS)	1.3	2.1	2.7
9	Turbidity (JTU) Dec. 1974 - April 1975	3	10	30
19	Specific Conductivity (micromhos)	750	1370	1750
19	Dissolved Oxygen (mg/1)	7.9	10.2	14.0
19	pH	7.2	8.2	8.8
19	Alkalinity (mg/1)	387	421	641
19	Bicarbonate (mg/1)	437	511	782
9	Carbonate (mg/1)	0	0	38
9	Nitrate (NO_3) (mg/1) Dec. 1974 - April 1975	7.5	7.9	8.4
19	Orthophosphate (mg/1)	0.00	0.03	0.15
19	Calcium (mg/1)	73	95	99
19	Magnesium (mg/1)	64	76	86
19	Sodium (mg/1)	120	120	250
19	Potassium (mg/1)	1.1	1.9	2.5
19	Chloride (mg/1)	6.0	7.0	16
19	Sulfate (mg/1)	330	370	380
19	Fluoride (mg/1)	0.1	0.3	3.3
19	Silica (mg/1)	14	15	17
19	Iron (μg/1)	10	20	620
19	Manganese (μg/1)	0	10	40
19	Dissolved Solids (mg/1)	865	950	1160

Table IX–9 MINIMUM-MAXIMUM AND MEDIAN CONCENTRATIONS FOR SELECTED WATER QUALITY CONSTITUENTS

U.S.G.S. NO. 09306025
WEST FORK STEWART GULCH NEAR RIO BLANCO, CO.
May 3, 1974 to November 20, 1974
Elevation – 6668 ft. above MSL

Total No. of Samples		Minimum	Median	Maximum
21	Temperature (°C)	0.0	12.0	30.0
17	Discharge (CFS)	0.02	0.03	0.15
–	Turbidity (JTU) Dec. 1974 - April 1975	-NR-	-NR-	-NR-
21	Specific Conductivity (micromhos)	1460	1620	2070
20	Dissolved Oxygen (mg/1)	6.6	8.8	13.5
20	pH	7.4	8.2	8.8
21	Alkalinity (mg/1)	374	437	621
21	Bicarbonate (mg/1)	438	533	757
12	Carbonate (mg/1)	0	0	13
	Nitrate (NO_3) (mg/1) Dec. 1974 - April 1975	-NR-	-NR-	-NR-
21	Orthophosphate (mg/1)	0.00	0.06	0.12
21	Calcium (mg/1)	48	95	130
21	Magnesium (mg/1)	84	100	120
21	Sodium (mg/1)	130	160	220
21	Potassium (mg/1)	1.2	2.8	9.8
21	Chloride (mg/1)	7.6	10	29
21	Sulfate (mg/1)	380	480	590
21	Fluoride (mg/1)	0.0	0.2	1.2
21	Silica (mg/1)	8.9	15	18
21	Iron (μg/1)	20	40	210
21	Manganese (μg/1)	0	0	20
21	Dissolved Solids (mg/1)	943	1130	1450

NR - Not Recorded (not a major station)

Table IX–10 MINIMUM-MAXIMUM AND MEDIAN CONCENTRATIONS FOR SELECTED WATER QUALITY CONSTITUENTS

U.S.G.S. NO. 09306058
WILLOW CREEK nr RIO BLANCO, CO.
April 23, 1974 to April 3, 1975
Elevation – 6273 ft. above MSL

Total No. of Samples		Minimum	Median	Maximum
30	Temperature (°C)	0.0	11.0	18.5
25	Discharge (CFS)	0.56	1.1	4.1
9	Turbidity (JTU) Dec. 1974 - April 1975	9	40	200
29	Specific Conductivity (micromhos)	1200	1390	1590
29	Dissolved Oxygen (mg/1)	7.7	10.0	12.6
29	pH	7.5	8.0	8.7
30	Alkalinity (mg/1)	395	425	476
30	Bicarbonate (mg/1)	482	515	580
22	Carbonate (mg/1)	0	0	9
9	Nitrate (NO_3) (mg/1) Dec. 1974 - April 1975	1.4	1.8	2.7
30	Orthophosphate (mg/1)	0.00	0.03	0.15
30	Calcium (mg/1)	64	97	100
30	Magnesium (mg/1)	70	76	87
30	Sodium (mg/1)	110	130	180
30	Potassium (mg/1)	1.1	2.3	5.0
30	Chloride (mg/1)	9.3	11	14
30	Sulfate (mg/1)	320	350	500
30	Fluoride (mg/1)	0.2	0.4	1.3
30	Silica (mg/1)	8.2	16	18
30	Iron (μg/1)	0	30	320
30	Manganese (μg/1)	0	20	70
30	Dissolved Solids (mg/1)	875	934	1150

Table IX–11 MINIMUM-MAXIMUM AND MEDIAN CONCENTRATIONS FOR SELECTED WATER QUALITY CONSTITUENTS

U.S.G.S. No. 09306061
PICEANCE CREEK ab HUNTER CREEK, nr RIO BLANCO, CO.
April 23, 1974 to April 3, 1975
Elevation – 6214 ft. above MSL

Total No. of Samples		Minimum	Median	Maximum
29	Temperature (°C)	0.0	14.0	23.0
22	Discharge (CFS)	4.6	6.3	31
6	Turbidity (JTU) Dec. 1974 - April 1975	10	50	300
29	Specific Conductivity (micromhos)	1140	1400	1660
27	Dissolved Oxygen (mg/l)	6.8	9.6	16.0
29	pH	7.5	8.2	8.7
29	Alkalinity (mg/l)	363	493	566
29	Bicarbonate (mg/l)	443	601	690
18	Carbonate (mg/l)	0	0	39
6	Nitrate (NO_3) (mg/l) Dec. 1974 - April 1975	2.6	2.9	3.5
29	Orthophosphate (mg/l)	0.00	0.09	0.25
29	Calcium (mg/l)	59	79	88
29	Magnesium (mg/l)	47	69	88
29	Sodium (mg/l)	120	160	200
29	Potassium (mg/l)	1.2	3.9	6.4
29	Chloride (mg/l)	11	14	16
29	Sulfate (mg/l)	220	300	380
29	Fluoride (mg/l)	0.3	0.7	1.5
29	Silica (mg/l)	12	17	20
29	Iron (μg/l)	10	30	880
29	Manganese (μg/l)	0	60	190
29	Dissolved Solids (mg/l)	736	944	1090

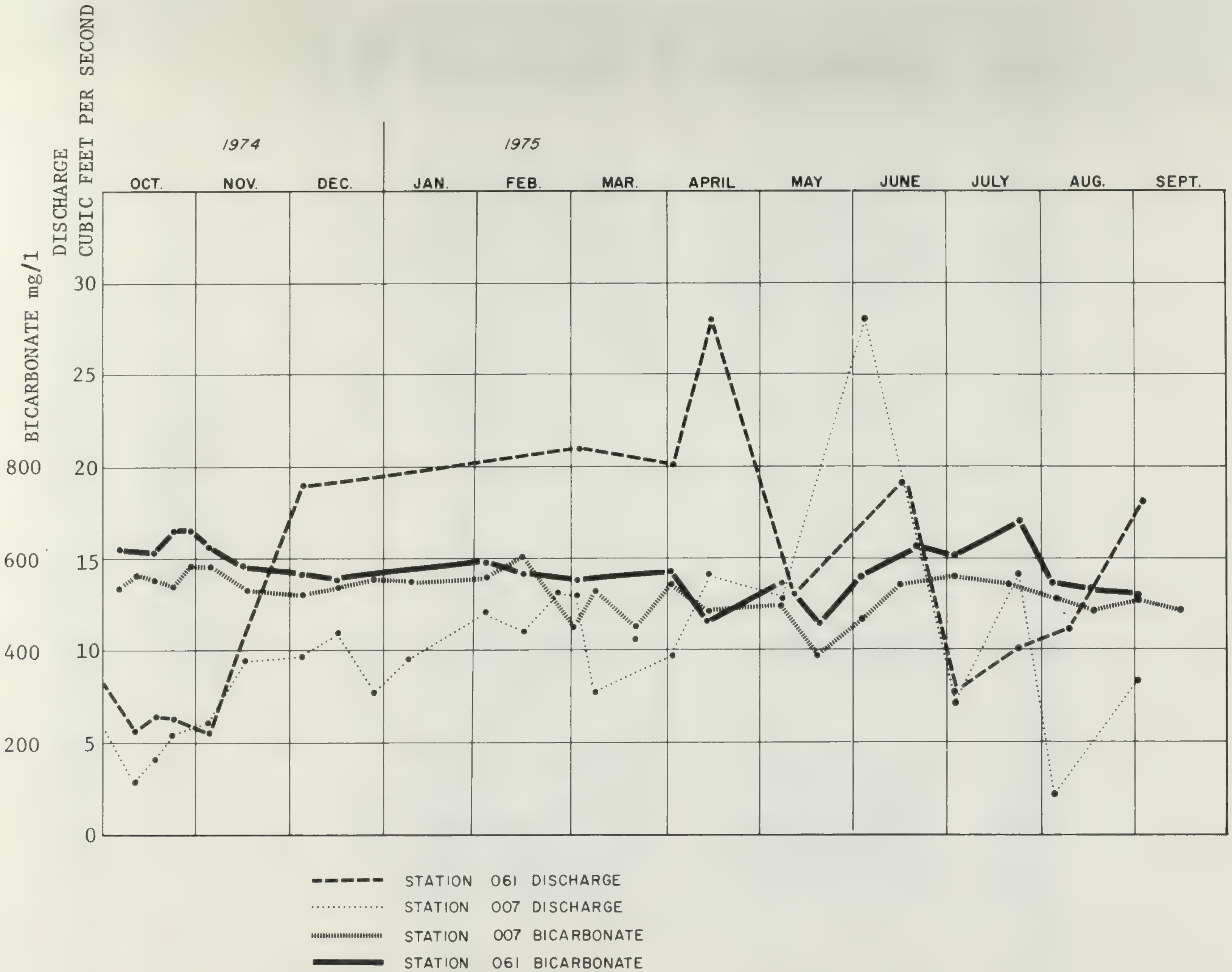


Figure IX–31 BICARBONATE CONCENTRATION AND DISCHARGE SURFACE WATER GAUGING STATIONS TRACT C-b AREA

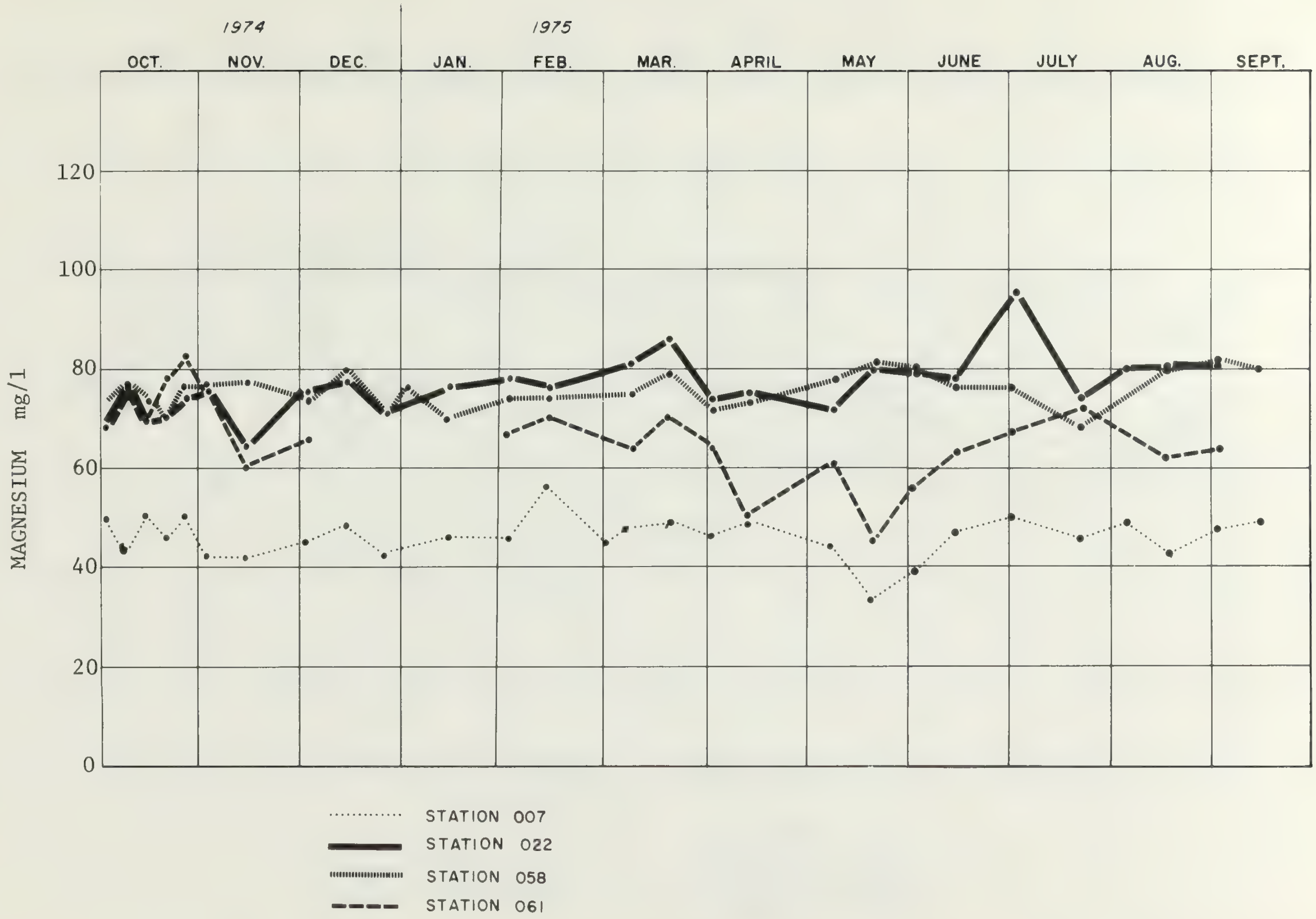


Figure IX—32 MAGNESIUM CONCENTRATION SURFACE WATER GAUGING STATIONS, TRACT C-b AREA

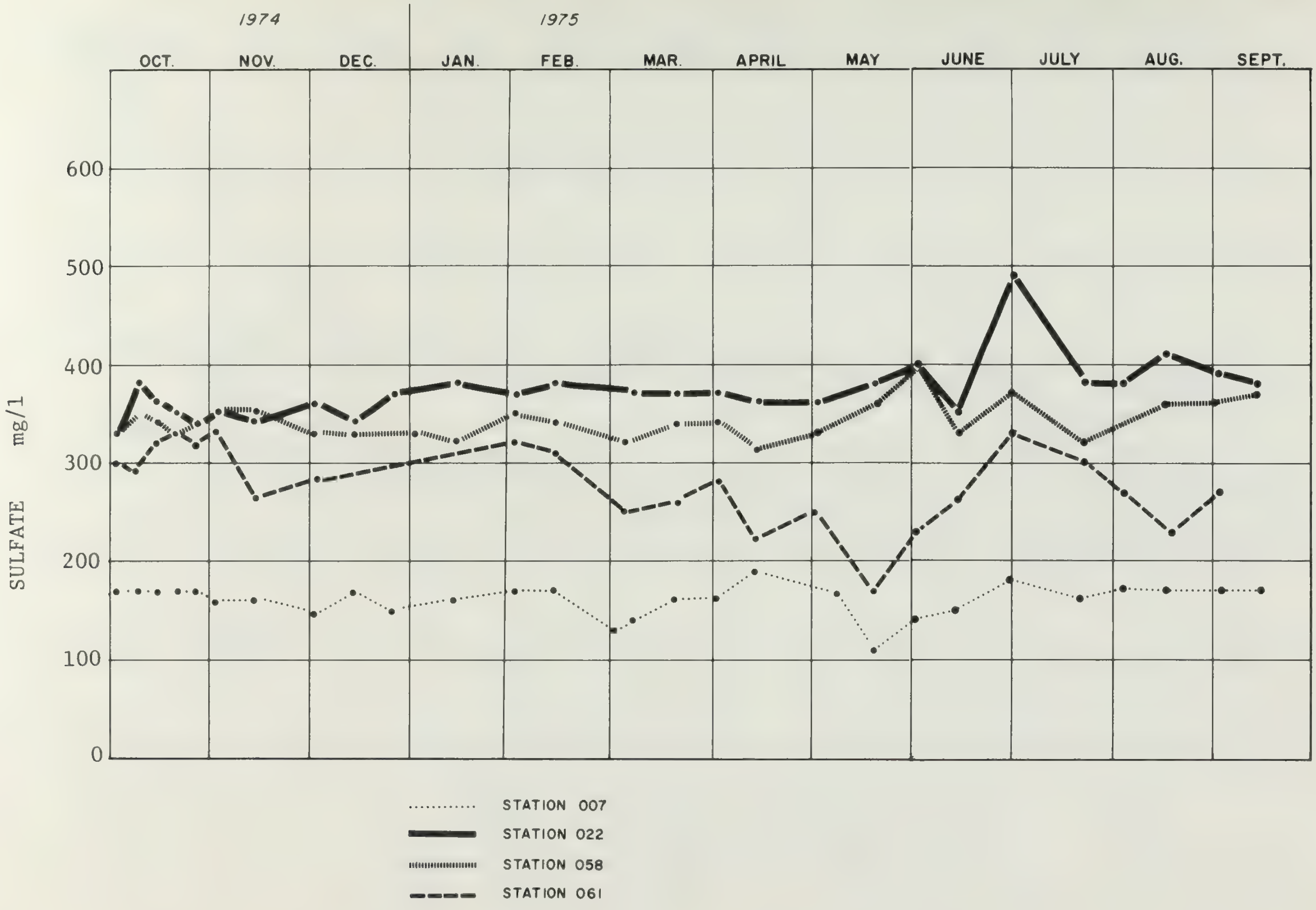


Figure IX–33 SULFATE CONCENTRATION SURFACE WATER GAUGING STATIONS, TRACT C-b AREA

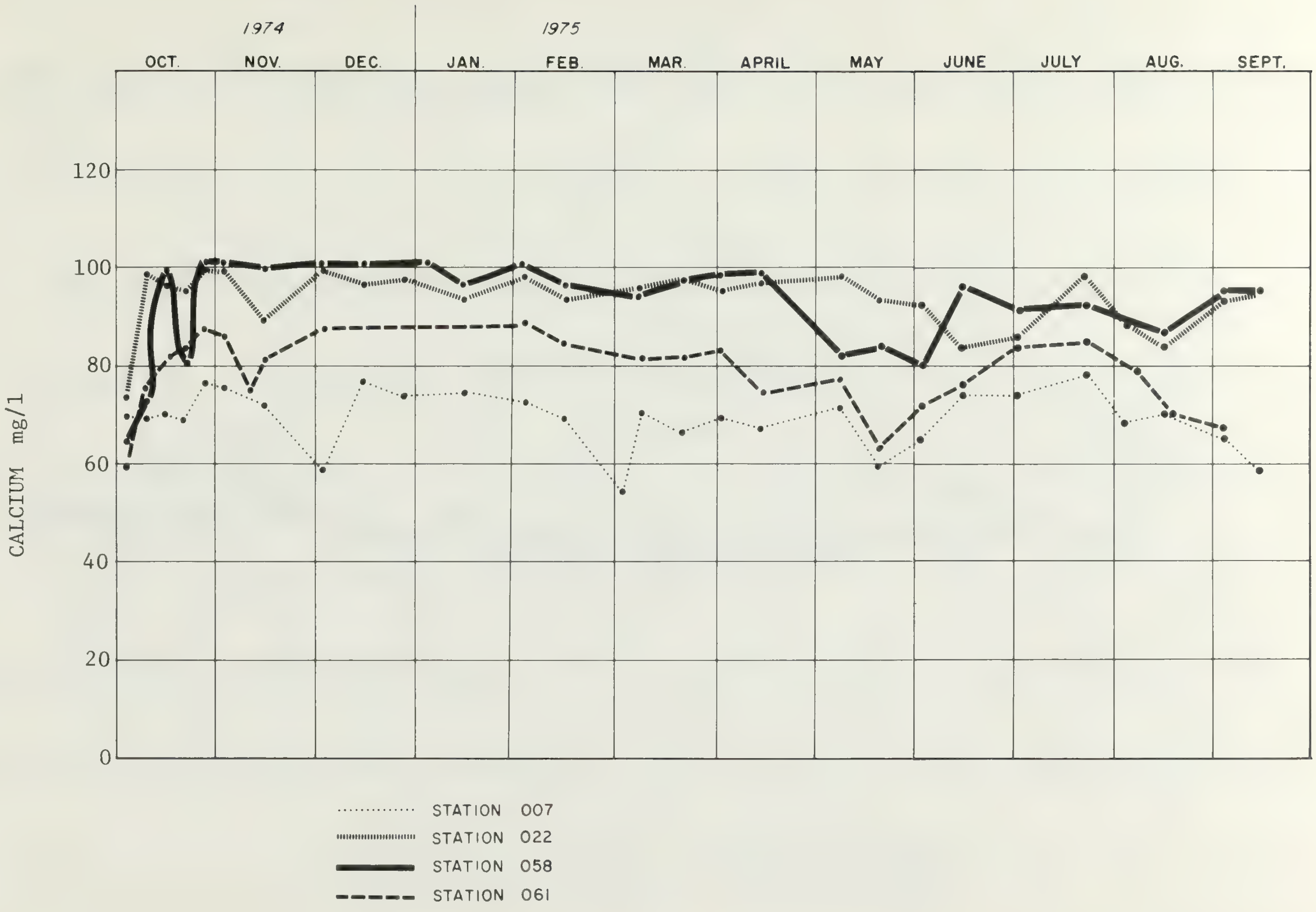


Figure IX—34 CALCIUM CONCENTRATION SURFACE WATER GAUGING STATIONS, TRACT C-b AREA

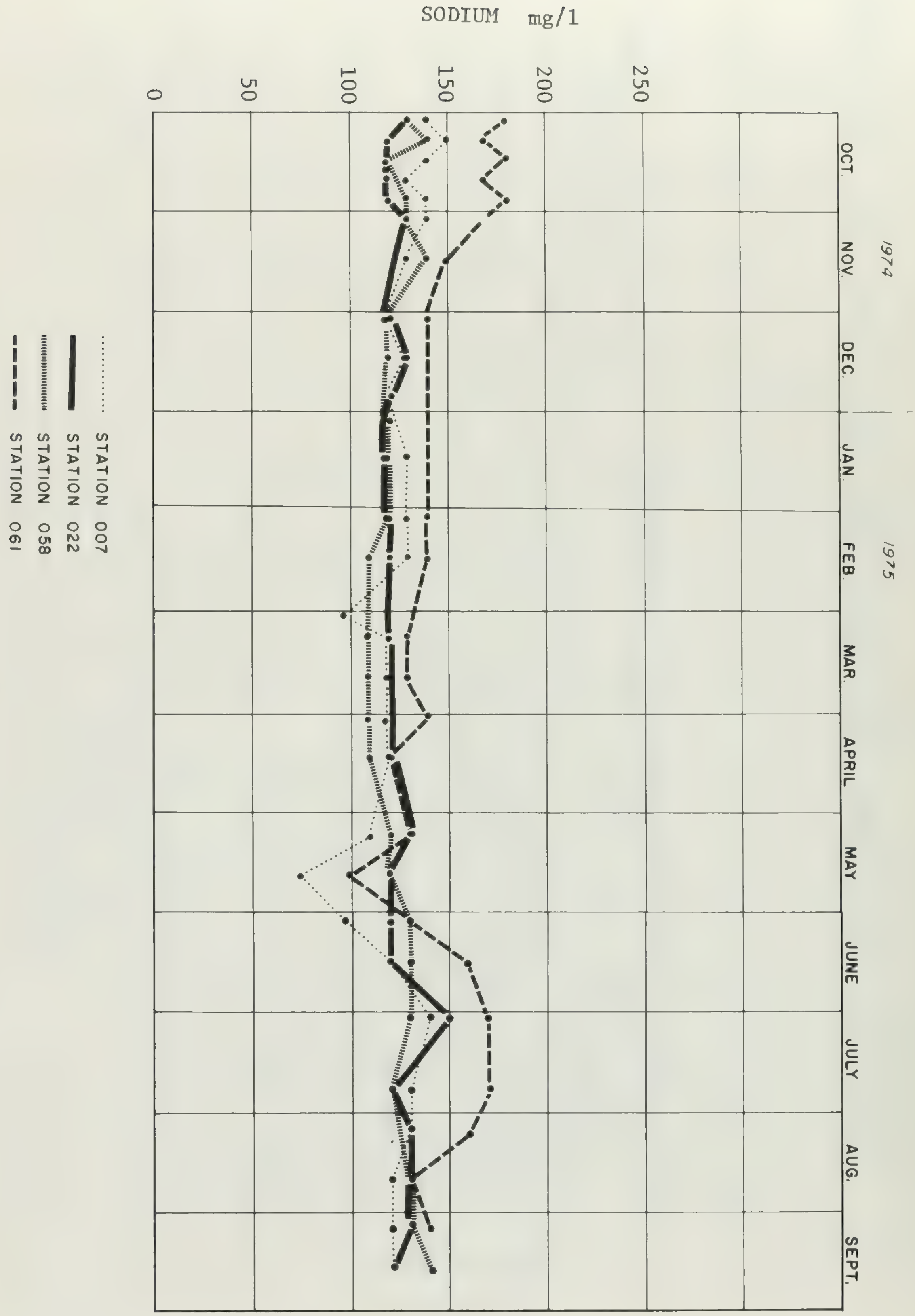


Figure IX–35 SODIUM CONCENTRATION SURFACE WATER GAUGING STATIONS, TRACT C-b AREA

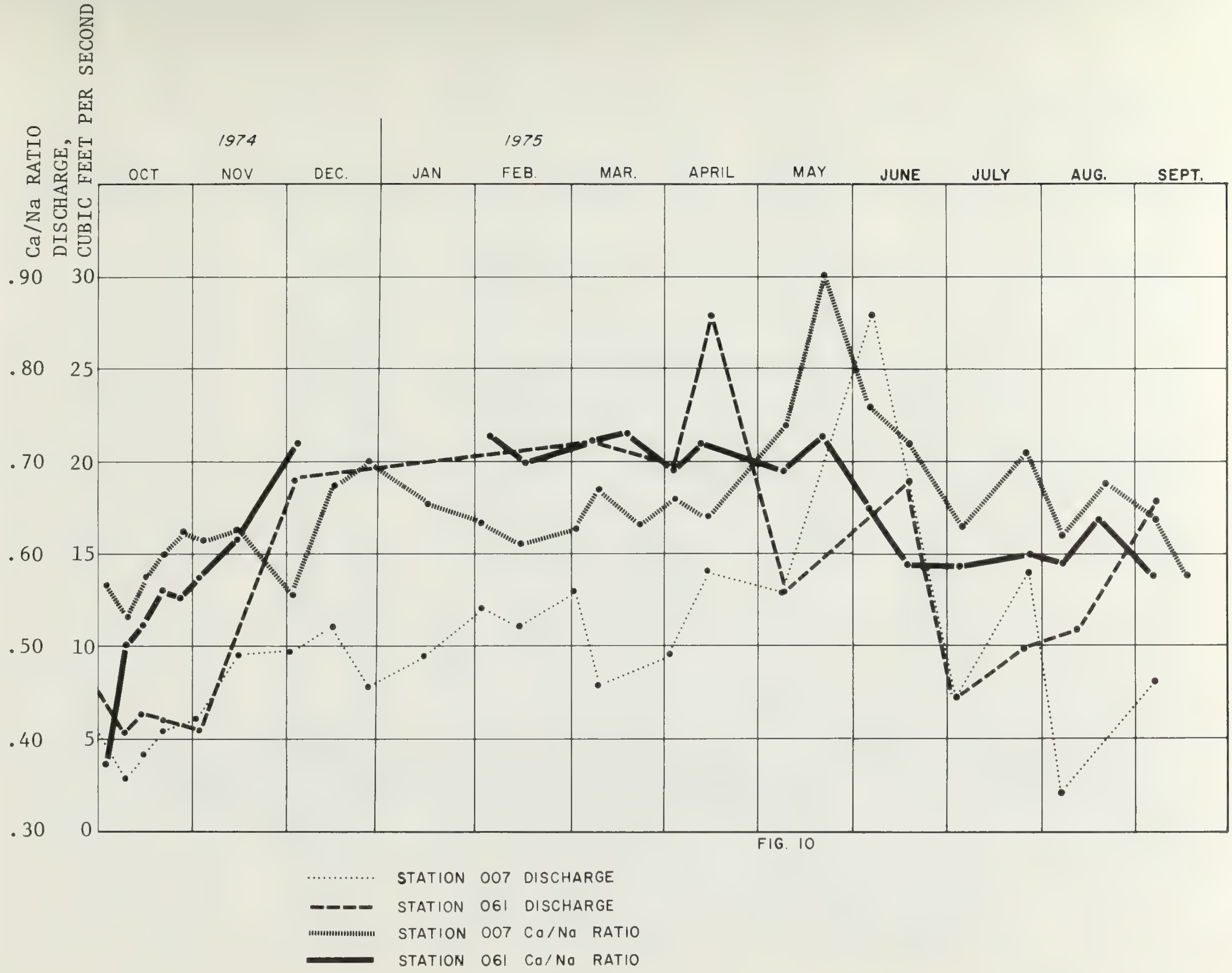


Figure IX—36 CALCIUM/SODIUM RATIO AND DISCHARGE SURFACE WATER GAUGING STATIONS, TRACT C-b AREA

FLUORIDE mg/1

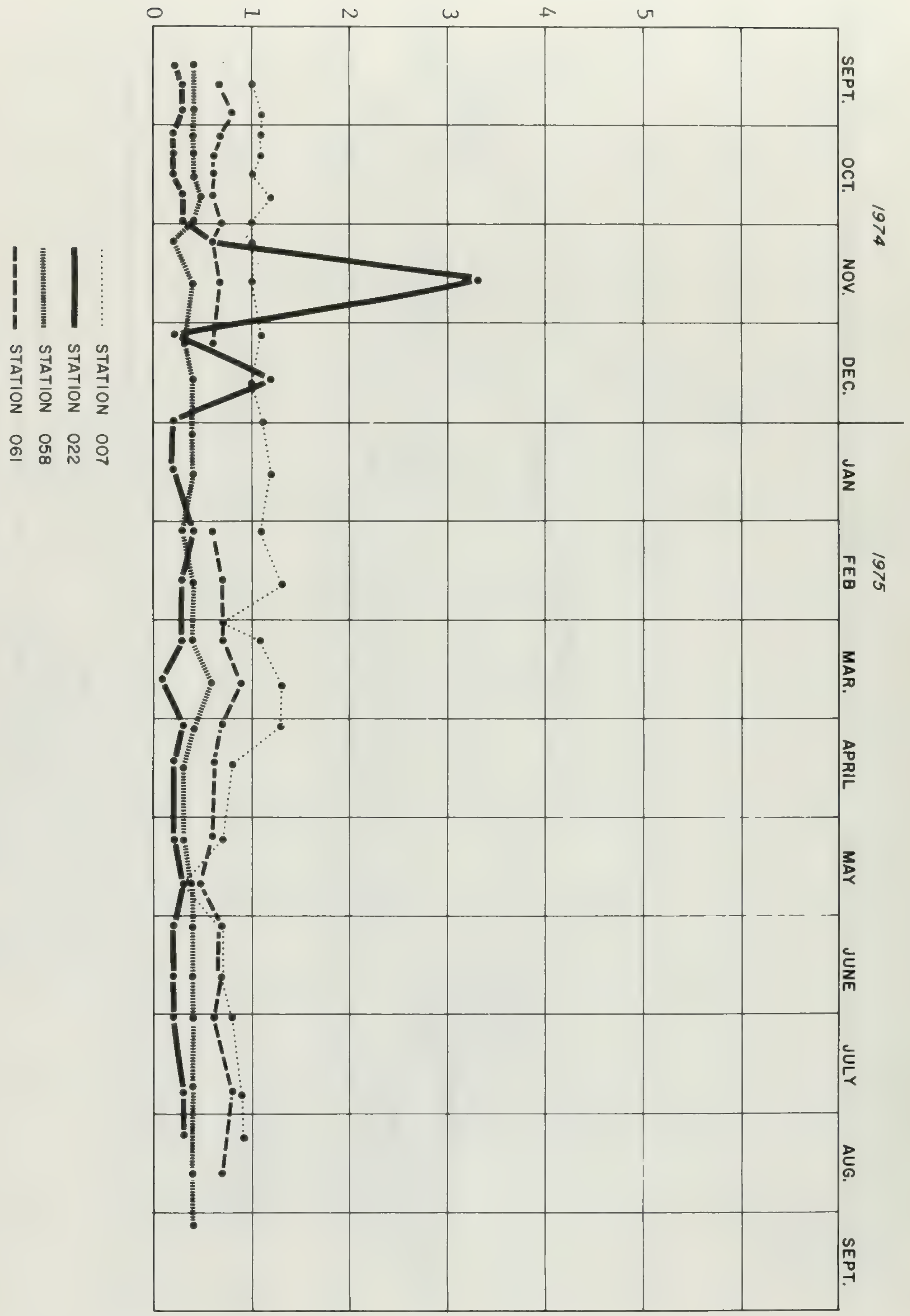


Figure IX–37 FLUORIDE CONCENTRATION – SURFACE WATER GAUGING STATIONS, TRACT C-b AREA

a definite increase in the concentrations of dissolved solids at low flows. Minimum flows during the summer 1974 were much lower than in 1975. This could be interpreted a classic dilution effect (where the base stream flow originates from ground-water sources with a high TDS content). During periods of storm runoff or snowmelt, the addition of higher quality runoff water results in a diluting effect and a lower concentration of dissolved solids. The increase in TDS during the irrigation season also can be related to the irrigation process and the leaching from the fields being irrigated. Based on the observed differences between 1974 and 1975 water-year data, the flow in Piceance Creek during relatively wet years is high enough that the dissolved solids concentration remains unaffected by irrigation and also overshadows the input from highly saline springs and seeps. During low-flow years these factors begin to assert themselves.

An indication of the degree of pollution of a stream can be obtained by plotting a pollution index, such as dissolved oxygen, against flow. For a heavily polluted stream, dissolved oxygen would be expected to increase with flow. Data from stations 007 and 061, plotted in Figure IX-38, do not exhibit the characteristics of a heavily polluted stream.

Specific conductivity measures the ability of a solution to carry electrical current and is an indirect measure of total dissolved solids. For a stream which fits the simple dilution model for flow, conductivity will decrease with increasing flow, because the increased flow resulting from surface runoff will carry a lower TDS load. Flow in the main stream of Piceance Creek, as illustrated by station 007 (Figure IX-39), does show a slight trend toward lower conductivity with increasing flow, thus tending to confirm the dilution model for stream flow. Flow in the tributaries, however, illustrated by the Willow Creek station, 058 (Figure IX-40), exhibits almost uniform conductivity regardless of flow. This indicates that these streams carry few pollutants from other than natural sources.

In Figure IX-41, sediment concentration is plotted against flow on log-log paper for station 061. This shows that, in general, the sediment load increases with increasing flow. This again confirms the model of a stream with base flow originating from springs, and therefore, having a lower sediment load than the surface runoff waters which account for increased flows.

Several of the trace elements being monitored have been found only in very low concentrations, near the lower limit of detectability. These values are below USPHS standards for drinking water. Table IX-12 compares those values observed to date with these standards. Sampling frequency will probably be changed from semimonthly to quarterly or annual sampling in the future. Research on the inorganic constituents of natural water has shown that the ion proportions are near constant or adequately related to the flow, and that the ion concentrations are deterministically related to the conductivity. Once the estimates of ion proportions are made within

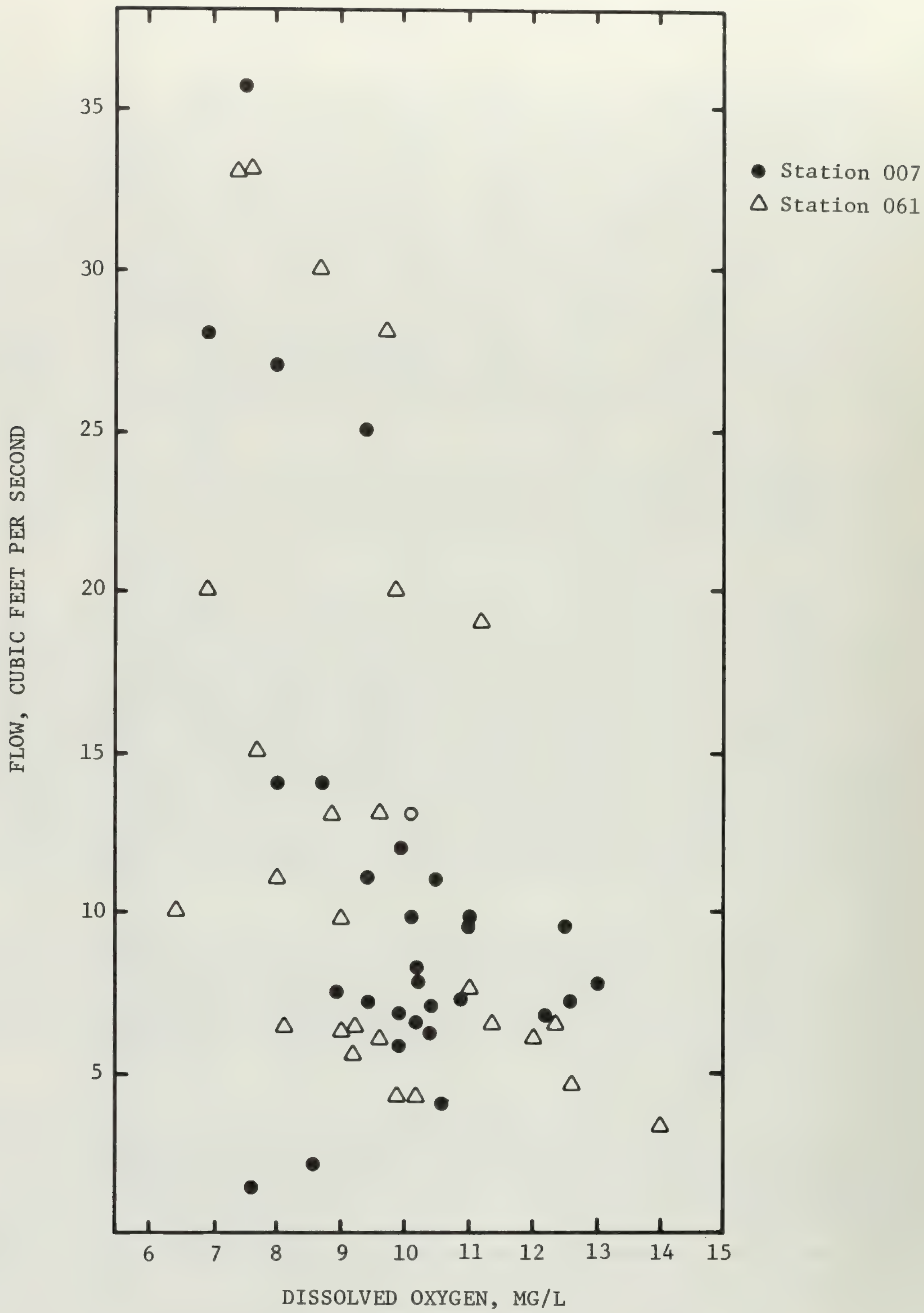


Figure IX—38 DISSOLVED OXYGEN VERSUS FLOW

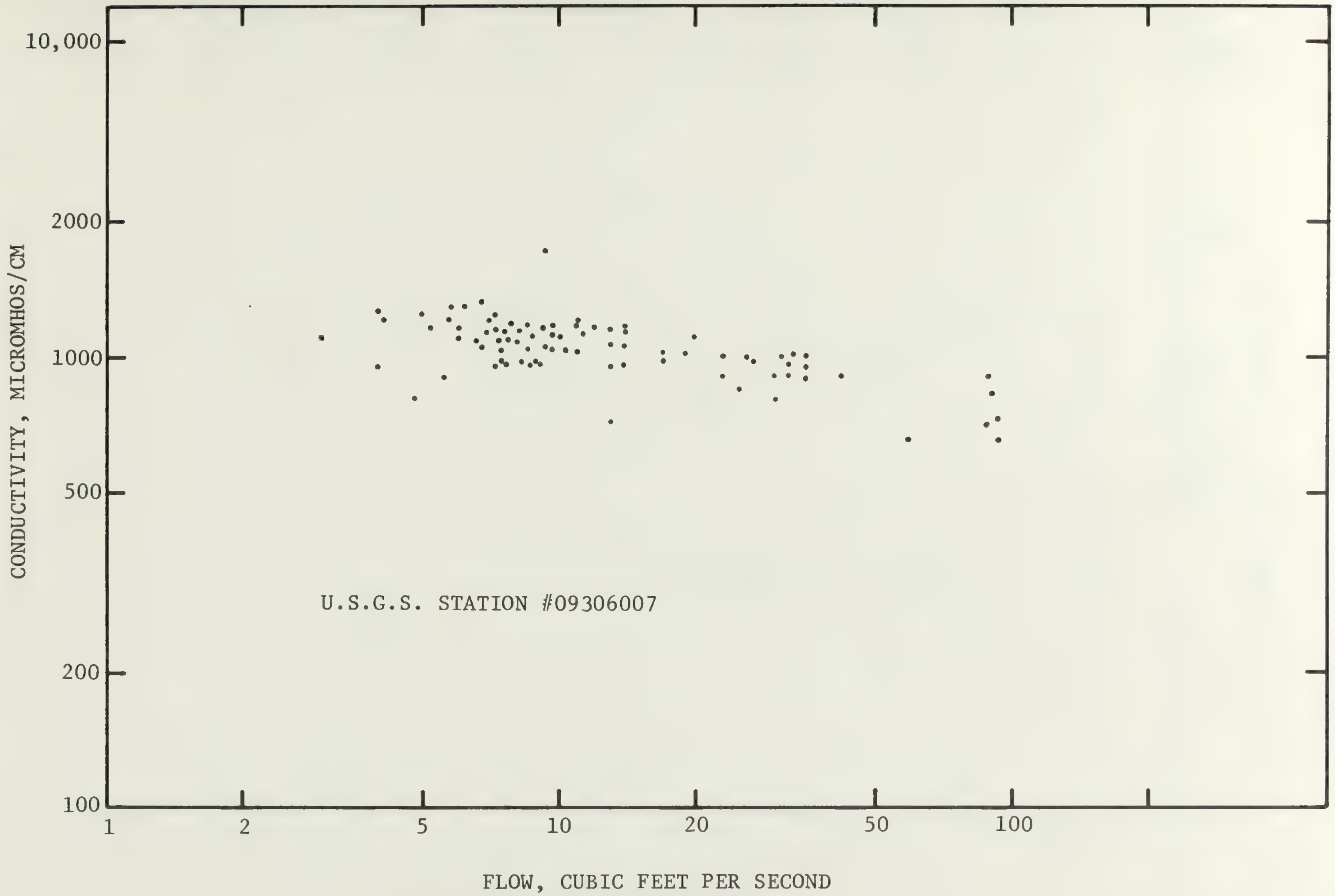


Figure IX—39 CONDUCTIVITY VERSUS FLOW, MAINSTREAM PICEANCE CREEK

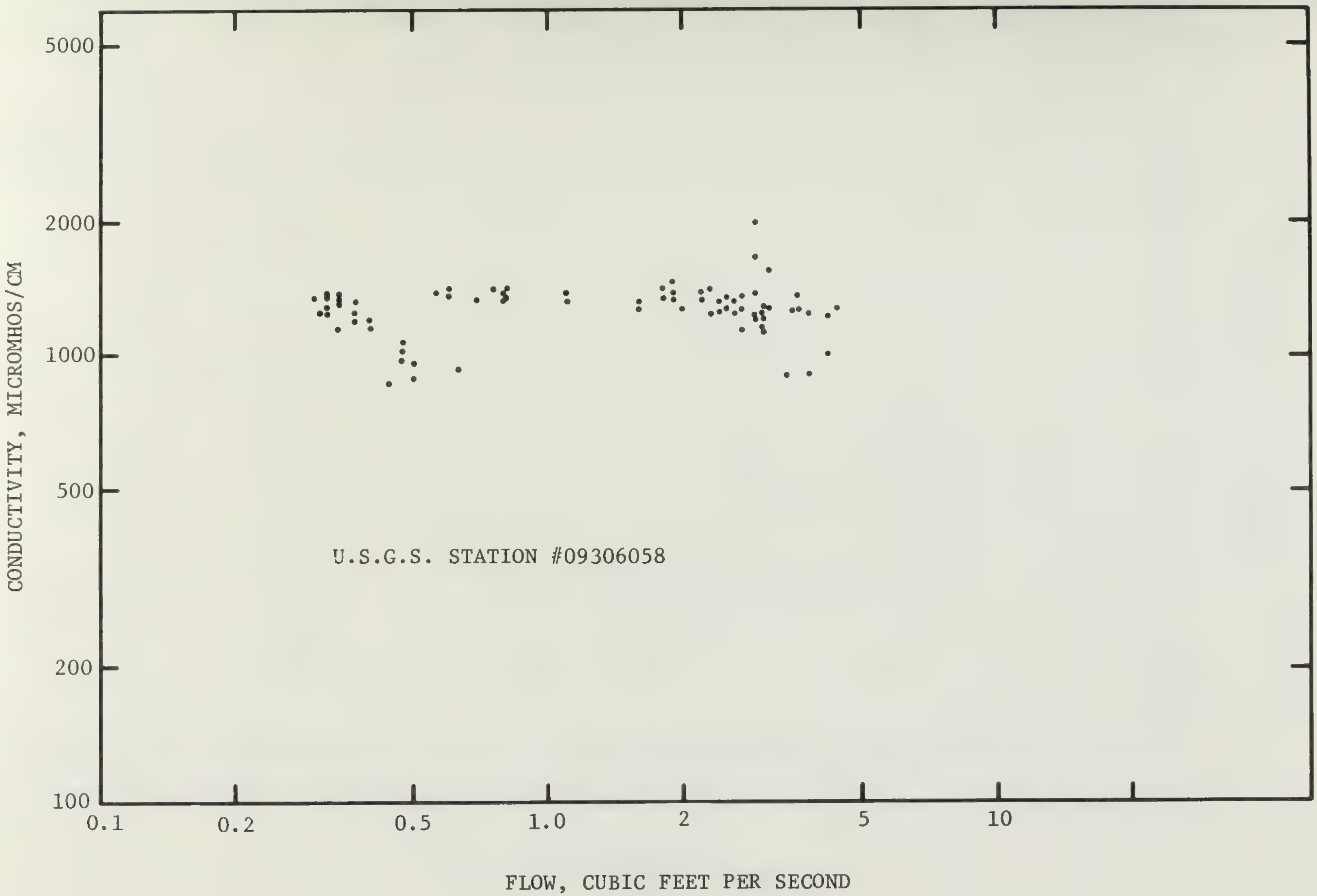


Figure IX—40 CONDUCTIVITY VERSUS FLOW, TRIBUTARY TO PICEANCE CREEK

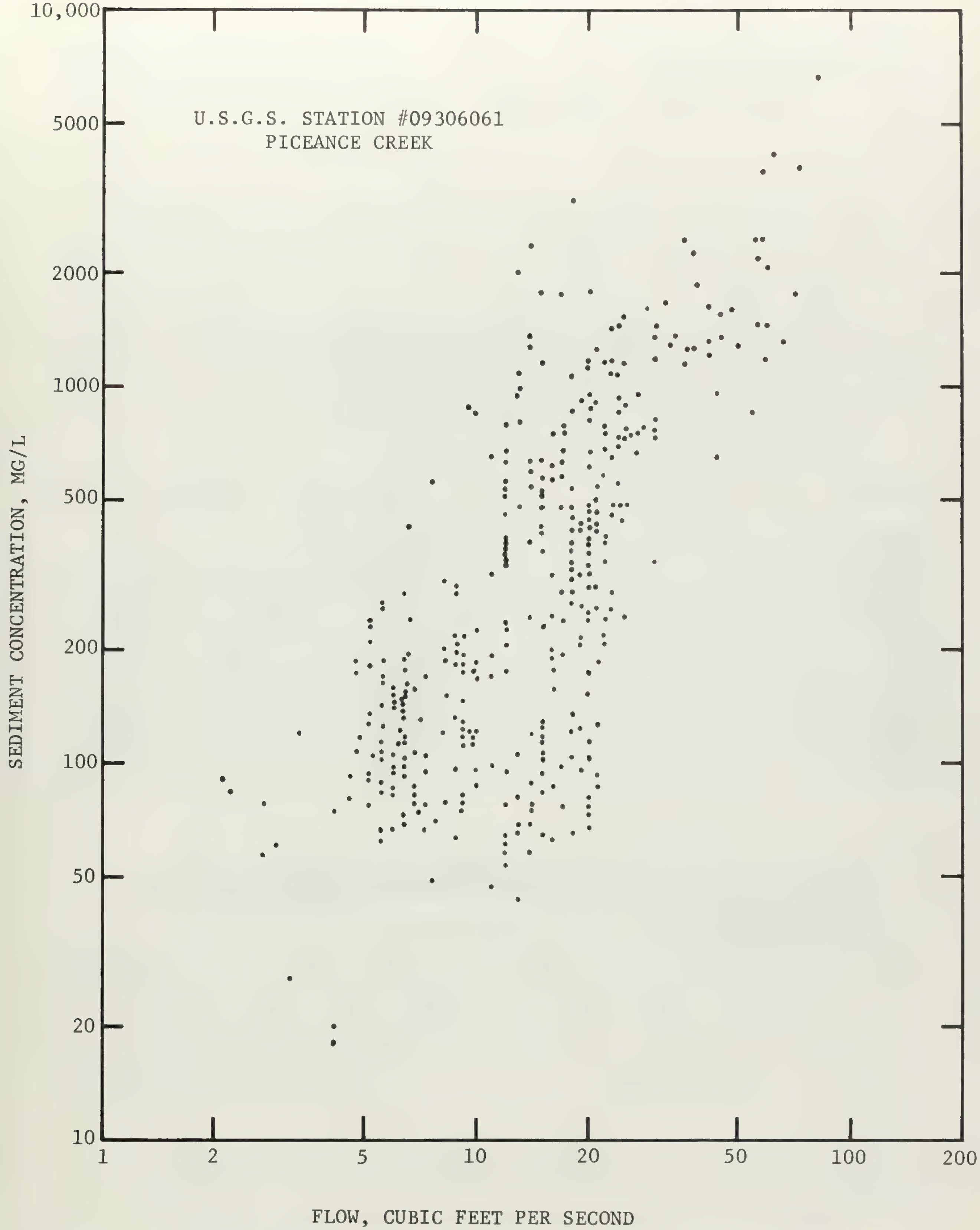


Figure IX-41 SEDIMENT CONCENTRATION VERSUS FLOW

Table IX–12 COMPARISON OF SURFACE WATER QUALITY
TO DRINKING WATER STANDARDS
Concentrations in Milligrams/Liter
(April 1974 – April 1975)

Element	Minimum	Maximum	Public Health Limit
arsenic	0	0.006	0.05*
barium	0	0.200	1.0*
cadmium	0	0.020**	0.01*
chromium	0	0.020	0.05*
copper	0	0.020	1.0
cyanide	0	0.01	0.2*
lead	0	0.020**	0.05*
lithium	0	0.056	***
mercury	0	0.0009	0.002
selenium	0	0.005	0.01*
zinc	0	0.370	5.0

* Drinking water standards – rejection of water supply if exceeded.

** A maximum reported as less than implies the lower limit of detectability for the analytical method used.

*** No standards set.

acceptable confidence limits, inorganic water quality can be determined from conductivity, which is being measured on a continuous basis. Only in the case of suspected pollution would sampling be necessary.

(2) Springs and Seeps

While the data collected on seeps and springs are limited, some general observations can be made. There appears to be no major difference in water composition in the sources sampled (Tables IX-4 and IX-5). However, sources 1 through 5, in the Stewart Gulch drainage, appear to be slightly different from sources 6 through 10, in the Willow Creek drainage. Sources 6 through 10, for instance, have uniformly higher fluoride and titanium readings and lower nitrate readings than sources 1 through 5. Iron and aluminum levels also seem to be generally different. This might indicate that the waters in Stewart Gulch and Willow Creek are coming from different underground sources. The observed variations, however, are small and perhaps of doubtful statistical significance.

B. Subsurface Hydrology

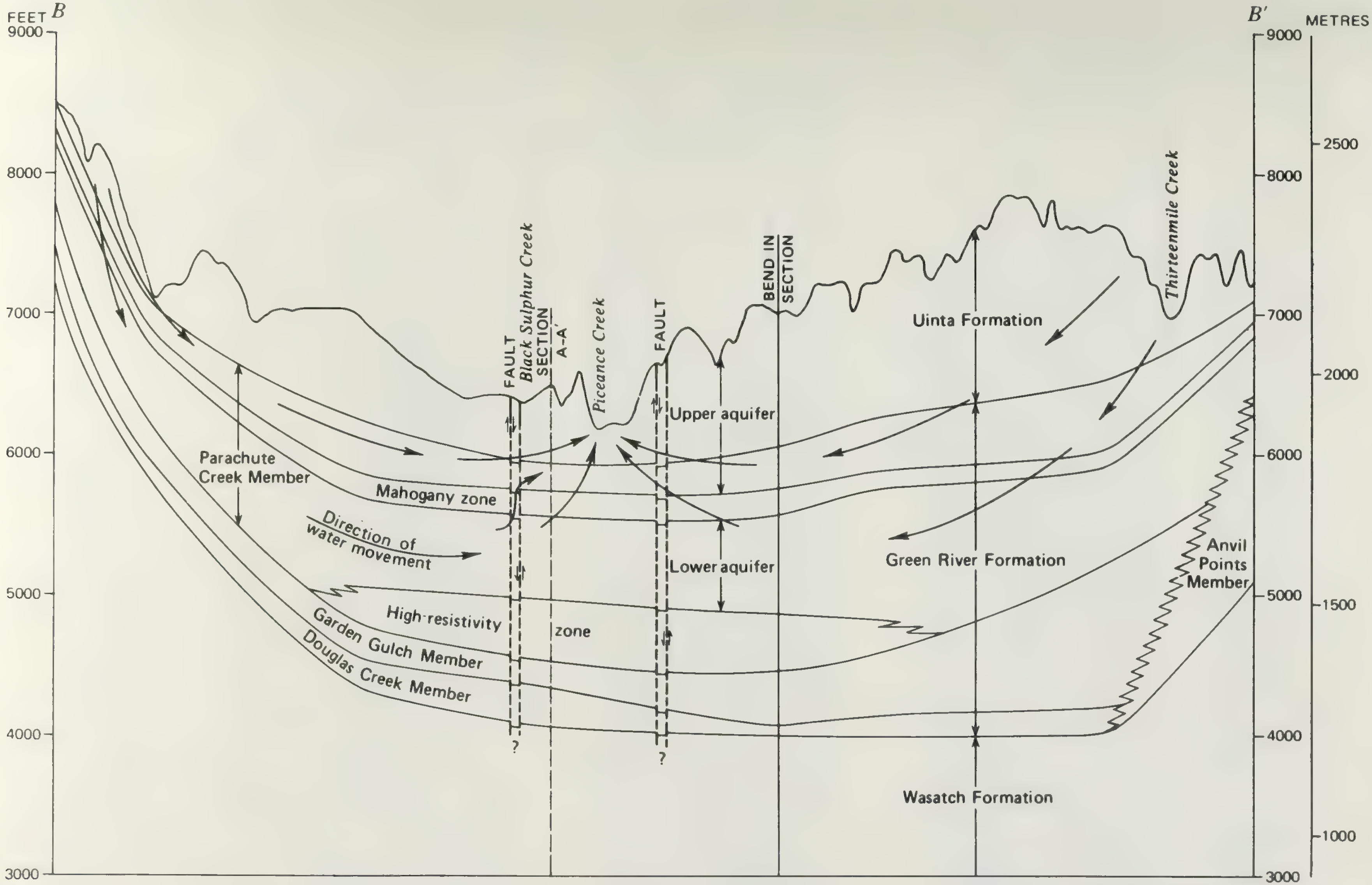
The data and interpretations presented in the recently-published USGS Piceance Creek hydrologic study (Weeks et al., 1974) were used as a basis for designing the initial subsurface hydrologic testing work conducted on the Tract. Subsequently, additional tests were performed to better define the aquifer systems. As a result of the multiple testing programs, it has been found that the USGS model of the basin is not entirely consistent with the new information developed on the Tract. These differences are described in the section on Tract Hydrology. As a basis for understanding the changes necessitated by the more recent work, the USGS interpretation of the ground-water hydrology is summarized below.

1. Regional Setting

a. Aquifer System

The 1974 USGS studies suggested that there are two major aquifers separated by the Mahogany zone. The upper aquifer consists of sandstone and fractured marlstone of the Unita formation and Upper Parachute Creek member of the Green River formation; the lower aquifer consists of fractured and leached marlstones of the Lower Parachute Creek member. The porosity and permeability of these aquifers is mostly the result of fracturing; however, in the Unita formation, primary porosity does play a role in fluid movement.

The Mahogany zone, shown in Figure IX-42, is a thick interval of rich oil shale 100 to 200 feet thick. In this paper it is the USGS thesis that only a layer 3-10 feet thick within this zone acts as the confining layer. This unit consists of 80-gallon-per-ton shale and is persistent throughout the basin.



Source: U.S.G.S. Professional Paper 908 (Weeks, et al., 1974)

Figure IX–42 GEOHYDROLOGIC SECTION THROUGH THE PICEANCE BASIN SHOWING RELATION OF THE AQUIFERS TO THE GREEN RIVER AND UINTA FORMATIONS

The alluvial aquifers are much less extensive, being confined to the valley bottoms. They are generally less than one-half mile wide and have a saturated thickness of generally less than 100 feet. The alluvium is principally composed of sand, gravel and clay.

b. Geohydrology

The USGS studies defined ground-water movement by mapping the potentiometric surface (Figure IX-43). In general, ground-water movement essentially parallels stream flow. The overall movement is to the north.

Most recharge to the aquifer system comes from spring snowmelt. In the recharge area the water percolates downward, charging the aquifer system, then laterally toward the discharge system.

The ground-water budget computed by the USGS is as follows:

> "The mean annual runoff from Piceance and Yellow Creeks has been estimated to be 15,650 acre-feet. Assuming that 80% of the runoff is ground-water discharge, the baseflow is estimated to be 12,500 acre-feet per year. The annual volume of evapotranspiration from the bottomlands is 41,200 acre-feet. The average precipitation is estimated to be 14.5 inches on the 22,800 acres of bottomland. This equivalent is 27,600 acre-feet per year. Substituting in the above equation, the estimated ground-water discharge from the basin is 26,100 acre-feet per year or 36.1 ft^3/s. Assuming steady state conditions, ground water is estimated to circulate through the aquifer system in the Piceance Creek basin at 36 ft^3/s.
>
> The volume of ground water in storage in the Piceance Creek basin has not been accurately determined. Coffin, Welder, and Glanzman (1971) estimated that the volume of water stored in the leached zone was 2.5 million acre-feet. On the basis of considerably more information, the Department of Interior estimated that as much as 25 million acre-feet of water may be stored in the Green River and Uinta formations in the Piceance Creek basin."

c. Hydraulics

The hydraulics of the entire basin were determined from 26 wells (Figure IX-44) and of this total only one was used to determine the storage coefficient for the upper aquifer. In general, the USGS found that upper aquifer transmissivities ranged from 8 ft^2/day to 1000 ft^2/day. It also found that the data are highly variable, which is to be expected in a nonhomogeneous fractured rock aquifer, and it found that the aquifer system is thin on the west side of the basin and thickens eastward. The transmissivity tends to increase from west to east.

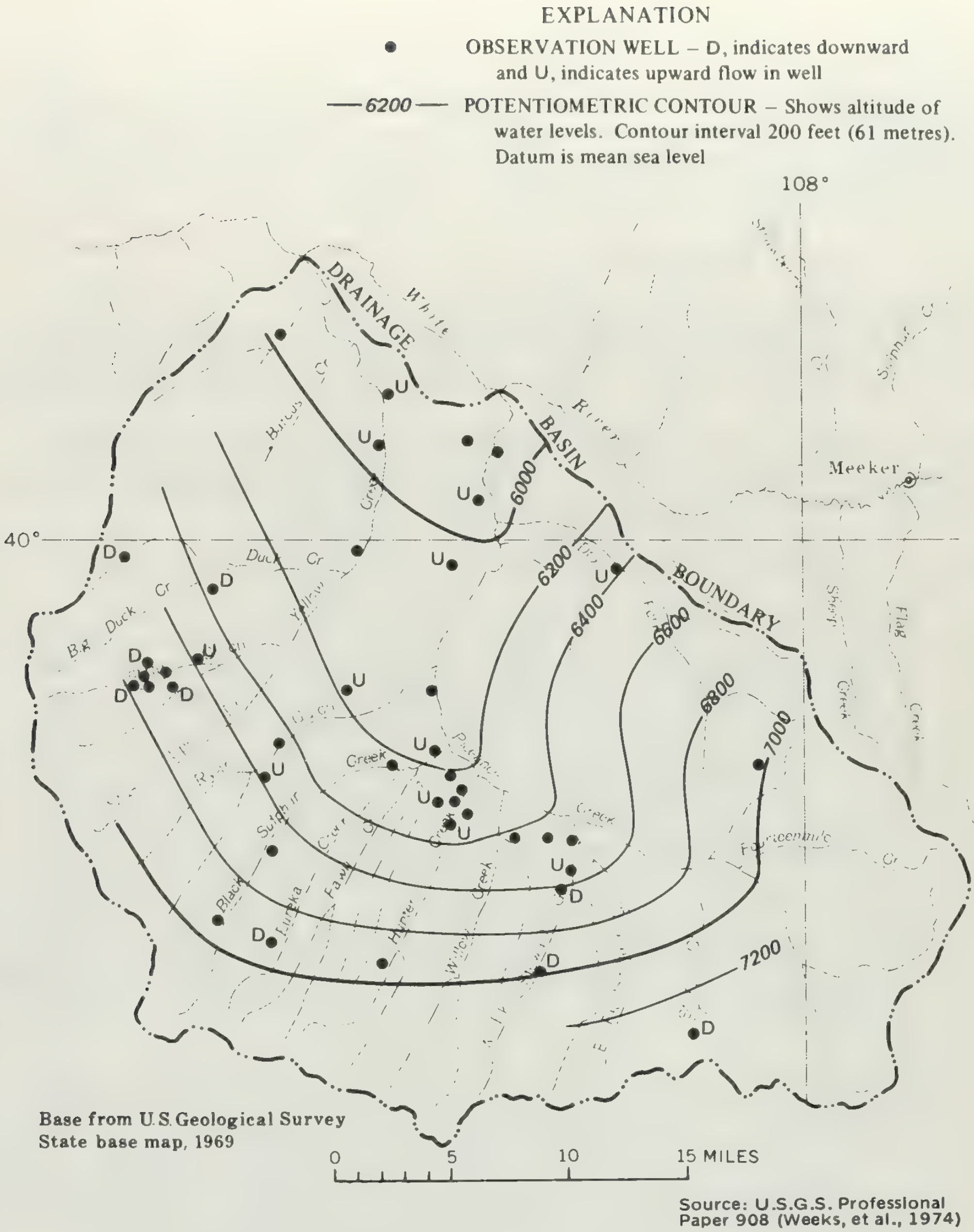


Figure IX–43 U.S.G.S. POTENTIOMETRIC MAP BASED ON WATER LEVELS IN WELLS OPEN TO BOTH THE UPPER AND THE LOWER AQUIFERS, APRIL 1974

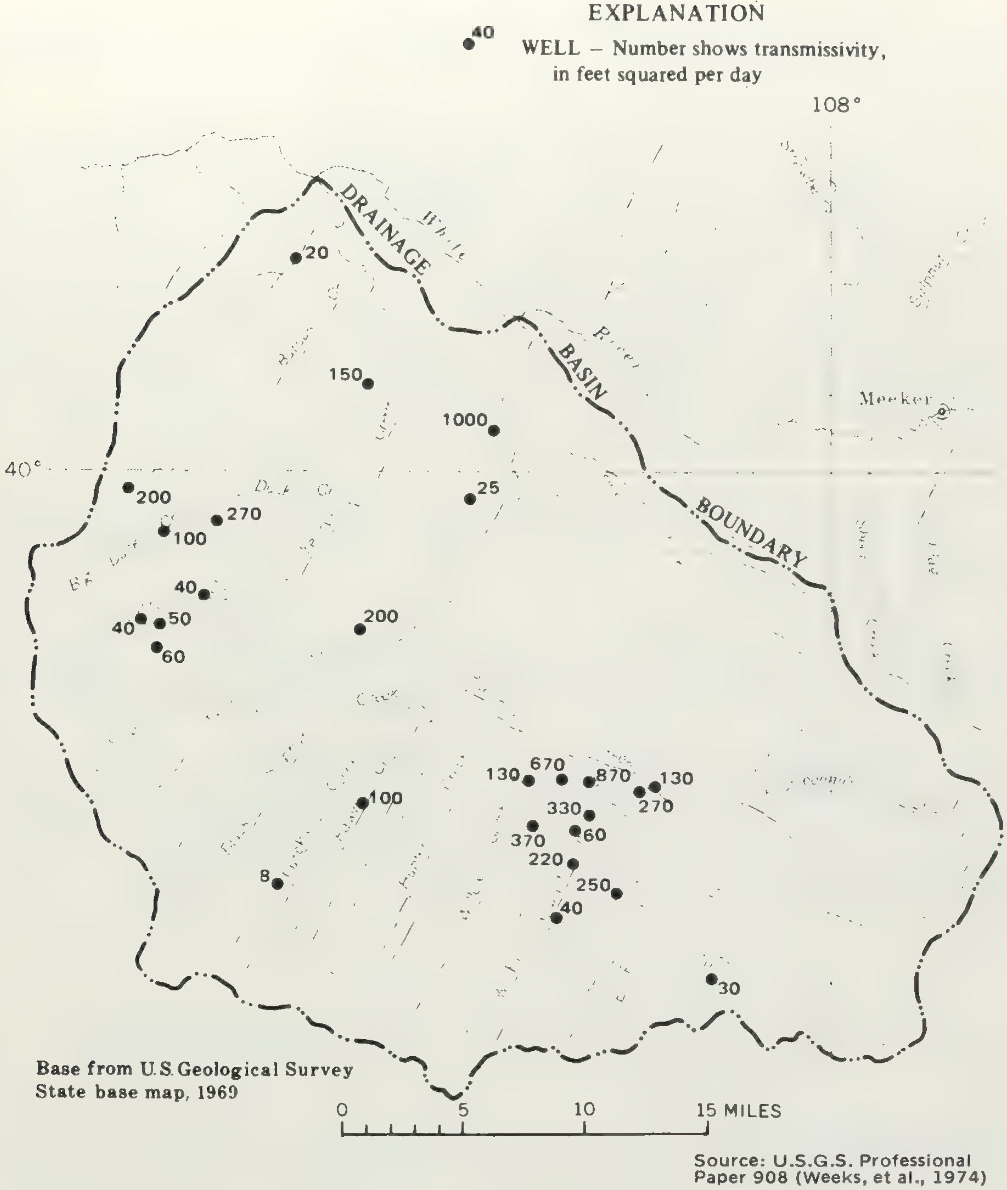


Figure IX—44 DISTRIBUTION OF TRANSMISSIVITY IN THE UPPER AQUIFER

The USGS established the storage coefficient of the upper aquifer as being in the order of 10^{-3}. In the outcrop areas the aquifer is unconfined and the specific yield is estimated to be between 10^{-2} and 10^{-1}.

Evaluation of the lower aquifer hydraulics were established on 20 wells (Figure IX-45). Three of these were used to determine the storage coefficient. The transmissivities ranged up to 1940 ft^2/day. Coffin, Welder and Glanzman (1971) reported that the transmissivity of the leached zone is as much as 2700 ft^2/day. The USGS pointed out that aquifer test data represent a small area of influence, and that the resultant transmissivity may not be typical of the region. It is believed, however, that the transmissivity should generally increase from the southeast to the northwest along the major structural axis of the basin.

Computations by the USGS indicated that the storage coefficient is in the order of 10^{-4}. In the outcrop areas the specific yield was estimated to be 10^{-1}.

The USGS paper suggested that indirect evidence indicates that the Mahogany confining zone must be generally permeable. An aquifer test was conducted at one site in the basin which showed no vertical permeability.

The transmissivity of the alluvial aquifers is highly variable, depending on the saturated thickness and occurrence of clay or silt. Measured transmissivity values range from 2700 to 20,000 ft^2/day. However, because of the limited areal extent of the alluvial aquifers, high discharge rates can be maintained only for brief periods.

d. Water Quality

This section presents a summary of the water chemistry discussed in USGS Professional paper 908.

According to this USGS study the chemical quality of ground water in the Piceance Creek basin varies both within and among the aquifers. Ground water from the alluvial, upper and lower aquifers generally does not meet the standards recommended by the USPHS (1962), although ground water is frequently used for stock watering and supplies some ranches. Water-quality data for the aquifers is summarized in Figure IX-46 and Table IX-13. The data show that water in the upper and lower aquifers is chemically different, and that water in the upper and alluvial aquifers is chemically similar.

Analyses have been made of water samples from 30 alluvial wells and springs in the major drainages in the Piceance Creek basin. The water in the alluvium is classified as a sodium bicarbonate type. The concentration of dissolved solids averages 1750 mg/l and generally increases in the downstream direction. The increase is due to irrigation return flows, ground-water discharge to the alluvium from deeper aquifers and concentration by evapotranspiration.

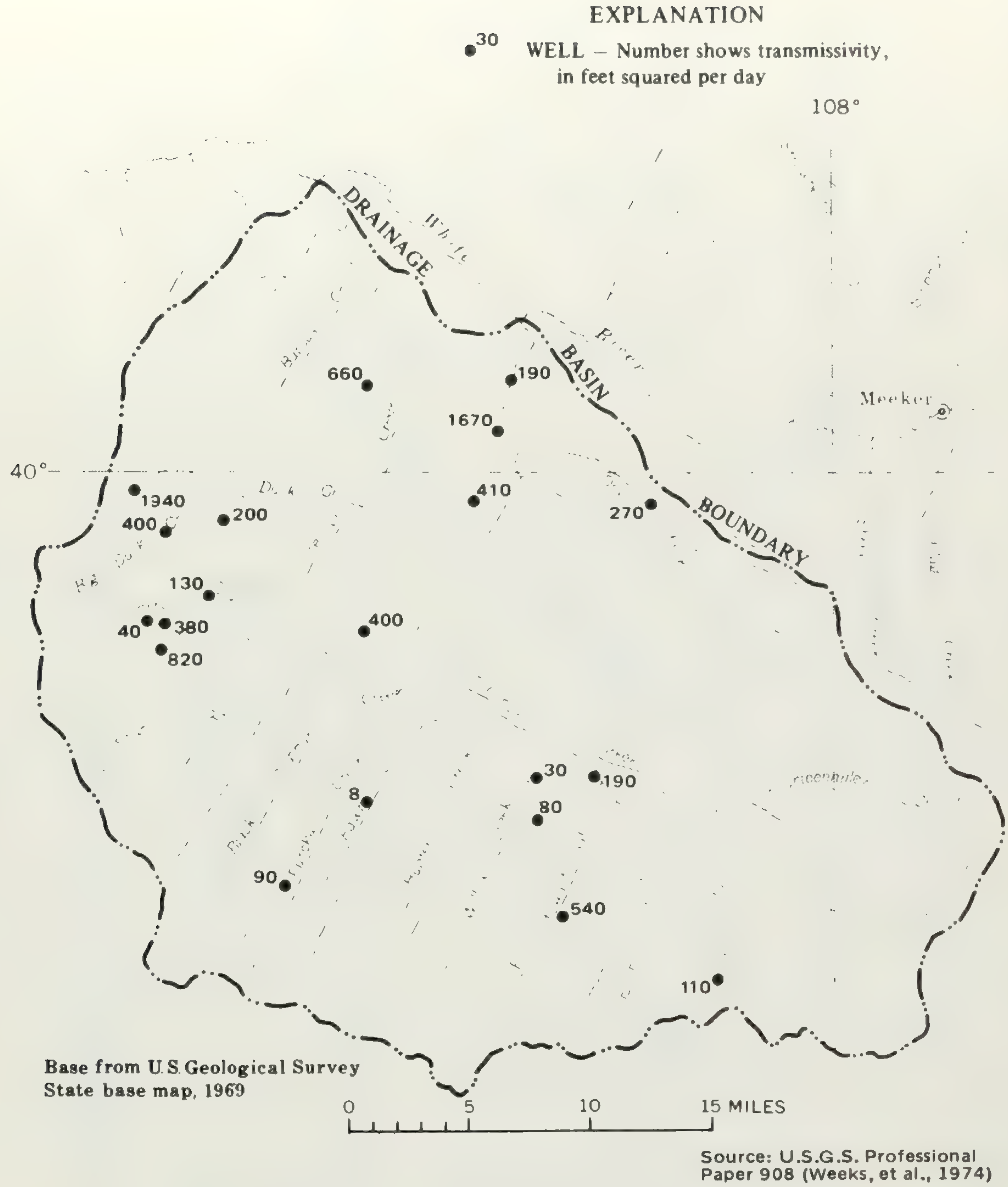


Figure IX–45 DISTRIBUTION OF TRANSMISSIVITY IN THE LOWER AQUIFER

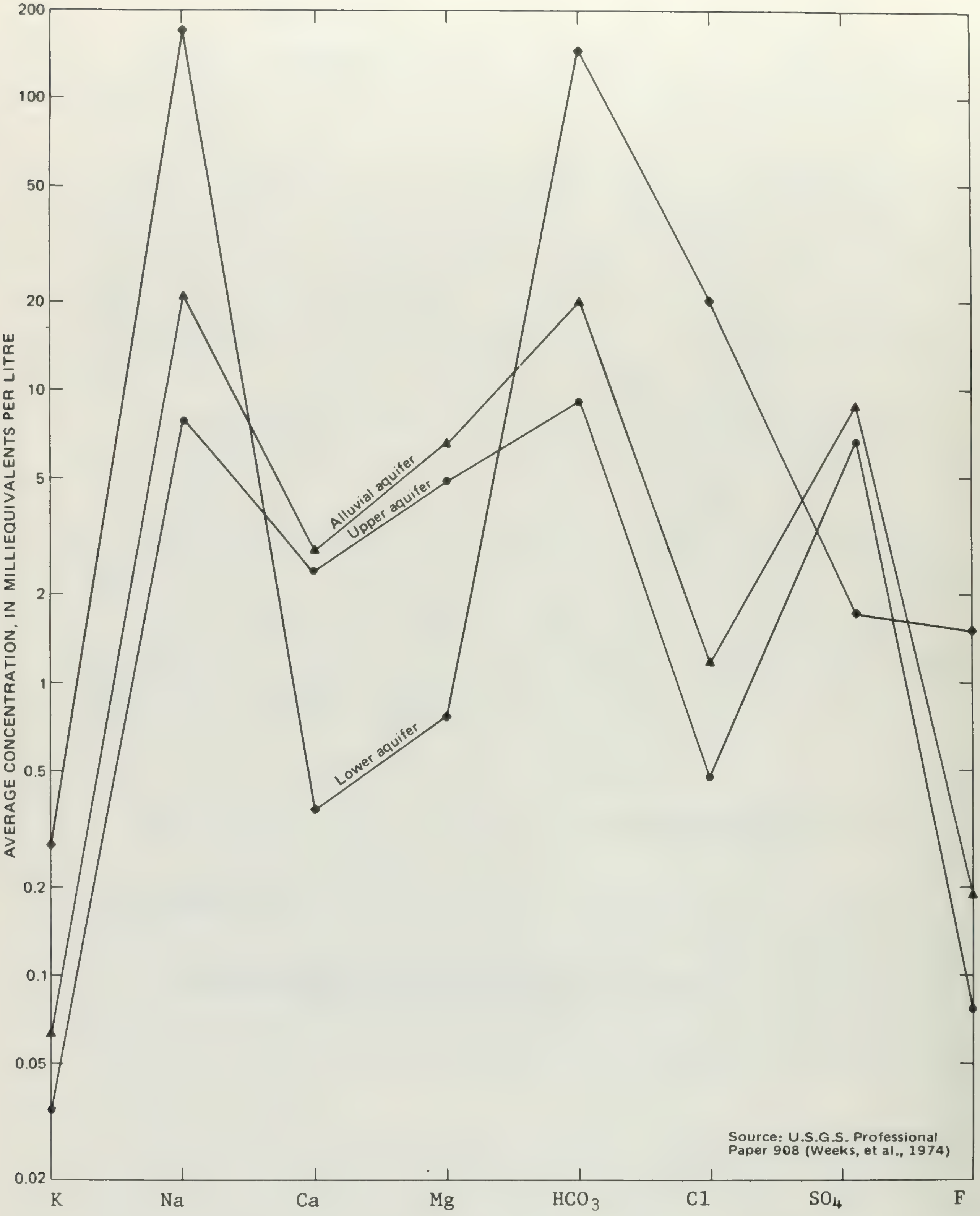


Figure IX–46 AVERAGE CONCENTRATION OF CHEMICAL CONSTITUENTS IN GROUND WATER

Table IX–13 SUMMARY OF WATER-CHEMISTRY DATA OF AQUIFERS

Chemical constituent	Concentrations, in milligrams per litre, in each aquifer								
	Alluvial			Upper			Lower		
	Minimum	Mean	Maximum	Minimum	Mean	Maximum	Minimum	Mean	Maximum
Potassium	0.8	2.5	6.8	0.2	1.5	6.0	0.4	11	78
Sodium	66	490	2,900	55	210	650	230	3,980	16,000
Calcium	2.4	57	120	7.4	50	110	2.8	7.4	15
Magnesium	3.6	80	160	9.8	60	187	3.0	9.5	26
Bicarbonate	336	1,220	3,560	307	550	918	493	9,100	40,000
Chloride	5.2	42	270	3.4	16	63	1.3	690	2,900
Sulfate	41	430	1,500	34	320	850	4.2	80	350
Fluoride	.1	4.6	33	0	1.4	12	5.0	28	66
Dissolved solids	469	1,750	6,720	345	960	2,180	491	9,400	38,900

Source: U.S.G.S. Professional Paper 908 (Weeks, et al., 1974)

The concentration of dissolved solids in water samples from the alluvium is shown in Figure IX-47. The concentration ranges from 470 to 6720 mg/l, except at spring S2 where the concentration is 22,100 mg/l. Several sampling sites along Piceance Creek have relatively high concentrations of dissolved solids and reflect the chemistry of the water discharging to the alluvium from the lower aquifer.

Analyses have been made of water samples collected at 19 locations from the upper aquifer (Figure IX-48). The water in the upper aquifer can be classified as a sodium bicarbonate type. The water generally contains moderate concentrations of sulfate and low concentrations of chloride and fluoride. Figure IX-46 shows the similarity of the water in the upper and the alluvial aquifers.

Figure IX-48 shows the variation of dissolved solids concentration in the upper aquifer. Values range from less than 400 mg/l to more than 2000 mg/l. The potentiometric map presented in Figure IX-43 has a similar contour consideration to Figure IX-48, demonstrating that the dissolved solids concentration of the water in the upper aquifer increases in the direction of flow. The increase is due to the solution of minerals and to the water moving upward from the lower aquifer. Figure IX-48 also shows the effects of dilution from recharge along the divide between Piceance and Yellow Creeks.

The chemical composition of the water in the upper aquifer varies as it moves from the recharge area to the discharge area. In the recharge area, the ground water is generally a sodium-magnesium bicarbonate type, with sulfate making up nearly 50% of the anion concentration. As the water moves toward the north-central part of the basin, sodium and bicarbonate increasingly dominate the ionic concentrations.

Water-quality data has been obtained from water samples collected from 27 wells in the lower aquifer. Figure IX-46 shows a difference in water chemistry between the lower aquifer and the upper and alluvial aquifers. The graph shows that water from the lower aquifer is a definite sodium bicarbonate type with higher chloride and fluroide concentrations and lower sulfate concentrations than water from the other aquifers. Water from the lower aquifer is extremely low in calcium and magnesium content; and the sulfate ion concentration in this aquifer is generally lower than in the other aquifers in the basin. Hydrogen sulfide gas also is present in many samples collected from the lower aquifer. These facts indicate that reducing conditions exist in the lower aquifer, preventing oxidation of the sulfide ion.

The fluoride concentration in the lower aquifer is shown in Table IX-13. The average fluoride concentration is 28 mg/l and was found to be more than 10 mg/l in all but one sample. The maximum concentration found was 66 mg/l.

The concentration of dissolved solids in the water of the lower aquifer is moderate to extremely high. Table IX-13 shows that the

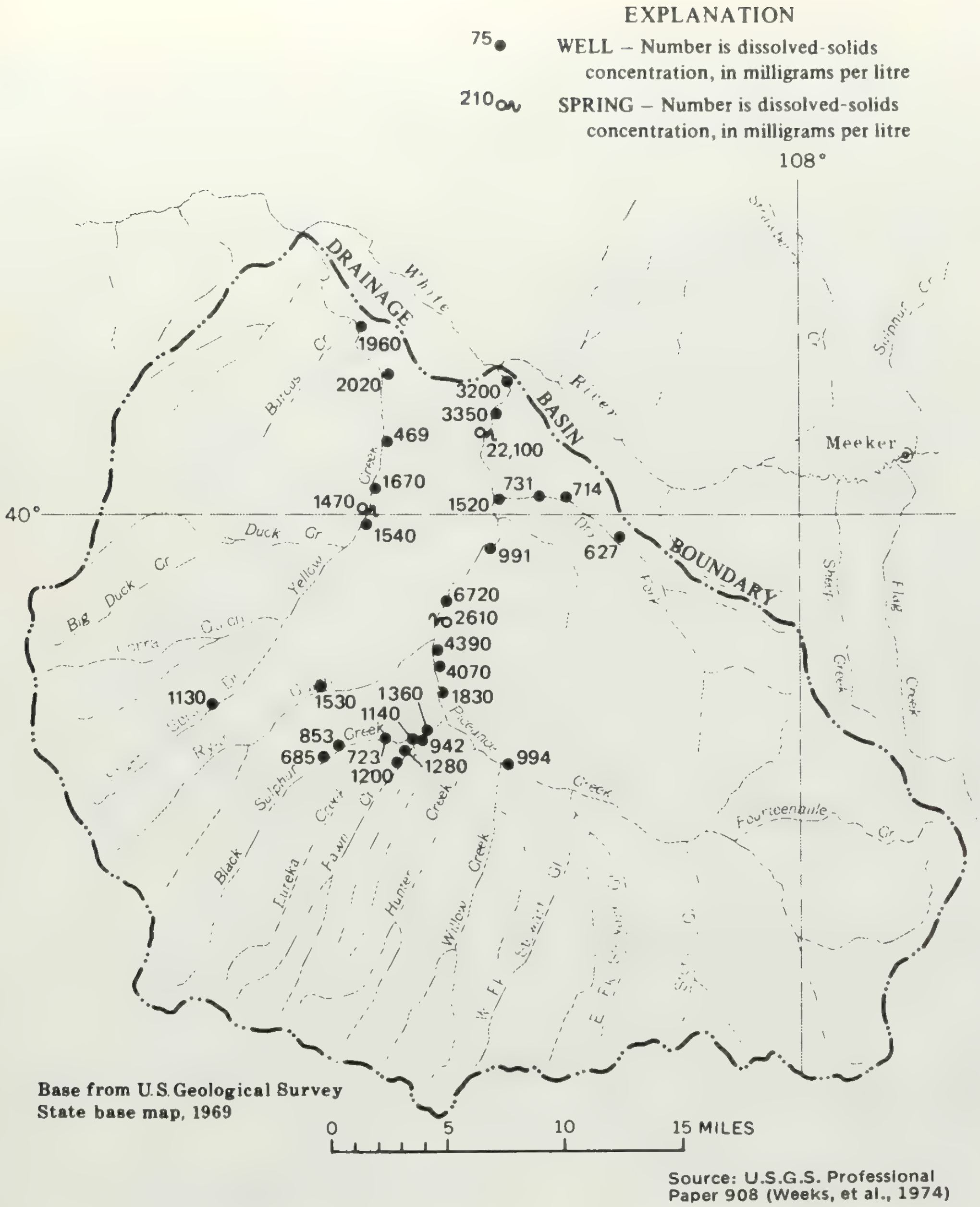


Figure IX–47 DISSOLVED-SOLIDS CONCENTRATION IN THE ALLUVIAL AQUIFER, MAY-SEPTEMBER 1974

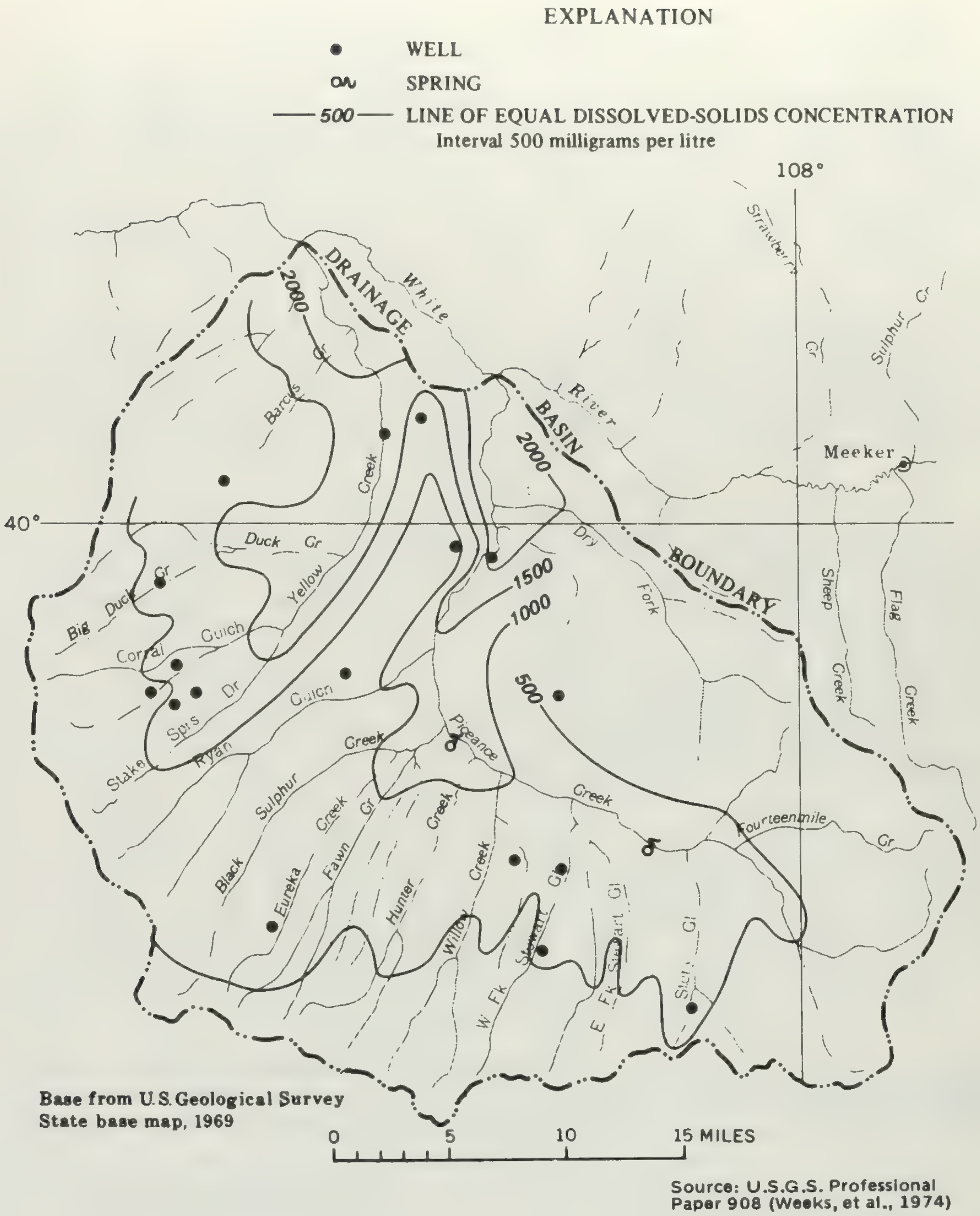


Figure IX–48 CONCENTRATION OF DISSOLVED-SOLIDS IN THE UPPER AQUIFER, MAY-SEPTEMBER 1973

dissolved solids concentration ranges from less than 500 mg/l to nearly 40,000 mg/l. However, a dissolved solids concentration of 63,000 mg/l in a water sample obtained from the high resistivity zone has been reported. The variation in the concentration of dissolved solids in the lower aquifer is illustrated in Figure IX-49. The contours on Figure IX-49 similar in shape to the potentiometric contours shown in Figure IX-43. This is the result of the solution of minerals as the water moves from the basin margins toward the north-central part of the basin.

The ground water in the lower aquifer contains many trace elements. The concentrations of barium, boron and lithium are consistently high in the northern part of the basin. Here, boron and lithium are present in amounts exceeding the levels determined to be toxic to most plants. Barium is present in the lower aquifer in excess of the 1000 μg/l value recommended by USPHS (1962) as the limit for drinking water.

2. Tract C-b

The Tract is located in the southeastern part of the Piceance Creek basin about midway between the ground-water intake and discharge areas of the basin. It is well away from that portion of the basin where maximum transmissivities, which are the result of leaching the abundant saline mineral deposits, are encountered. The ground-water quality at the Tract is intermediate between the fresher water at the outcrop and the highly saline waters in the northern central portion of the basin.

a. Program Description

During the past year, the Lessee has been conducting detailed hydrologic investigations of the multiple aquifer system beneath the Tract. The ultimate purpose of the program is to determine the local and regional effect of ground-water withdrawal. In general, the program involved jetting tests, pumping tests, drill-stem tests, water-quality sampling and water-level measurements. One or more of these tests were run on 34 wells drilled during the year. The wells are located in Figure IX-50. A brief description of the hydrologic testing program is given below. For additional details on the Tract testing program, refer to the Summary Reports.

(1) Drilling and Jetting Tests

Drilling and jetting tests were conducted as part of the drilling program on the Tract. During actual drilling operations, both discharge (water production) rates and electrical conductivities of the produced water were routinely recorded at approximately 30-foot intervals as part of the general well history. In addition, drilling operations were periodically shut down so that jetting tests could be conducted. In a typical deep well, jetting tests were performed at the following stratigraphic horizons: 1) base of the Uinta formation; 2) top of the Mahogany zone; 3) base of the Mahogany zone; 4) top of the R-4 zone; and 5) total depth. The zones are described further in Section VIII.

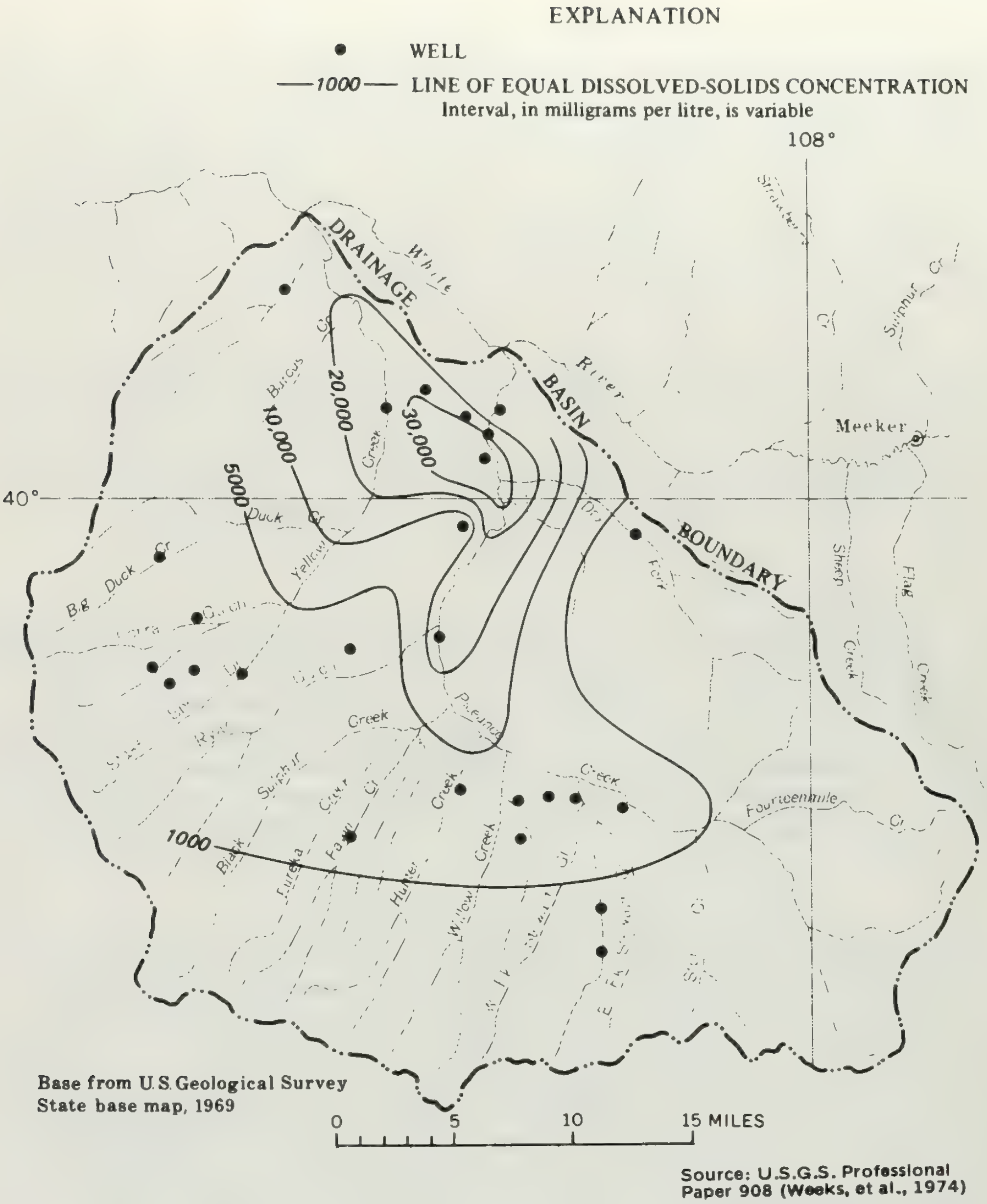


Figure IX–49 CONCENTRATION OF DISSOLVED-SOLIDS IN THE LOWER AQUIFER, MAY-SEPTEMBER 1973

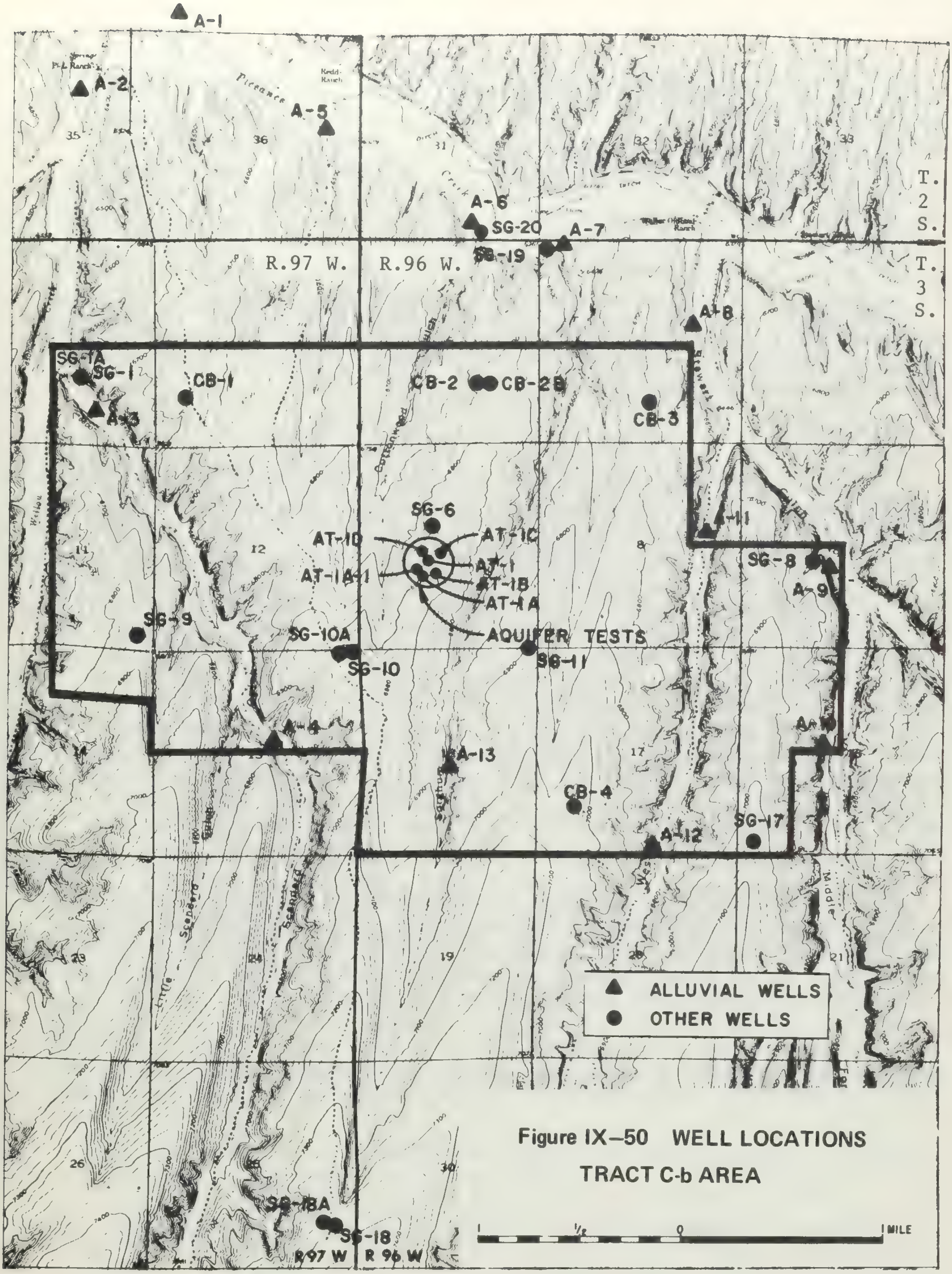


Figure IX–50 WELL LOCATIONS
TRACT C-b AREA

During each jetting test, air was blown down the drill pipe to the bottom of the hole to force the water to flow up and out of the hole. Discharge rates and continuous electrical conductivity of the produced water were recorded. After jetting was halted, measurements were made of the rate at which the water returned to the static level. Using the discharge data and water level recovery rates, the transmissivities of the various horizons are calculated.

(2) Pump Tests

To better define the aquifer characteristics, a series of pump tests were also conducted on the Tract. The pump tests can be grouped into three categories: main aquifer, mini-pump and alluvial aquifer. These tests are described below.

(a) Main Aquifer Pump Tests

The purpose of the main aquifer test was to determine the hydraulic characteristics of the main and lower aquifers beneath the Tract as defined by the USGS in its regional model of the basin. The main aquifer test was located near the center of the Tract (Figure IX-50).

The main aquifer tests can be described best as two separate tests. The first test consisted of a central pumping well surrounded by eight monitoring wells. The pumping well was completed in the upper aquifer. The monitoring wells were completed with multiple strings of tubing and packers which isolated the upper and lower aquifers in the observation wells. The producing well was pumped for 30 days, allowed to recover for five days, pumped for an additional five days and finally allowed to recover for 30 days. Responses of the upper and lower aquifers in the observation wells were recorded. Discharge rates, water level measurements and water production rates of the pumping well were continuously recorded. Water samples were collected on a regular basis.

The second main aquifer test was identical in concept with the first, except that the pumping well was deepened and recompleted so that only the lower aquifer could be pumped. In this test the producing well was pumped for 18 days, allowed to recover for eight days, pumped for an additional eight days and finally allowed to recover for 20 days.

Based on these data, computations have been made of transmissivity, storage coefficient and water production of the upper and lower aquifers. Vertical hydraulic conductivity of the Mahogany zone was also determined.

(b) Mini-Pump Tests

A series of short-term pump tests (called the mini-pump tests) were conducted on two wells (SG-1 and SG-1A), located about 100 feet apart in the northwest corner of the Tract (Figure IX-50). The principal purpose of this test series was to determine the extent to which thin zones of rich oil shale act as aquitards and restrict vertical flow.

The mini-pump tests consisted of a pumping well (SG-1A) and an observation well (SG-1). By means of multiple packer arrangements, the same aquifer unit was isolated in both the pumping and observation well. Recording devices were placed in the observation well to measure vertical flow through the aquitards into the isolated aquifer. Four intervals were tested using this procedure. The pumping periods lasted from 12 to 24 hours followed by recovery periods of two to six hours. The amount of water discharged by the pumping well was measured during the testing of each unit. From the information collected, computations were made of the vertical hydraulic conductivity of several aquitards. Transmissivities and storage coefficients of the four individual aquifer units were also determined. Water-quality samples were taken on a regular basis during testing, and water electrical conductivity was recorded hourly.

(c) Alluvial Aquifer Pump Tests

Aquifer pump tests were conducted on two shallow alluvial wells, A-1 and A-2 (Figure IX-50). The purpose of these tests was to obtain transmissivity data on the Tract to compare with regional data developed by the USGS. For these tests no observation wells were used and water-level measurements were taken in the pumped well itself. Discharge measurements were made with the use of a container and stop watch. Each well was pumped from four to six hours followed by a recovery period of two to four hours. Water-quality samples were collected at the close of the pumping period.

(3) Drill Stem Tests and Multi-packer Tests

Drill stem tests were conducted in three wells drilled on the Tract. The most comprehensive testing program was conducted in SG-17 where nearly 40 drill stem tests were run. Two drill stem tests were also run in each of the core holes SG-20 and SG-21.

In conducting each drill stem test, a packer was lowered on drill pipe to a predetermined depth. The packer was set (expanded) isolating the lower part at the hole. Water was jetted out of the drill pipe from the interval below the packer for a predetermined length of time. During jetting, discharge was measured and water samples collected. After the jetting was terminated, the rise or recovery in water level in the packed-off zone was recorded. Using discharge and recovery data, calculations were made of horizontal permeability.

The drill stem test has several important advantages over routine jetting tests:

- It allows a direct calculation of horizontal permeability for a particular small interval in the hole.

- It allows the collection of a water-quality sample from a small discrete subsurface interval.

- It can be used to provide a permeability and water-quality profile of how conditions change with depth.

In addition to the standard, single-packer drill stem tests, more sophisticated multi-packer tests were also conducted during the drilling of SG-17. A three-packer tool was assembled in which water could be selectively injected into very small packed-off intervals. Twelve intervals were tested by this method. In all the tests, water was injected into the primary packed-off interval at rates of 5, 10, 20 and 20+ gallons per minute. The change in pressures in the various zones was recorded. After completing the injections, the tool was loosened, raised to a higher interval, and another test was run.

The principal objective of the multi-packer testing was to determine vertical permeability. The configuration of the tool and packer assembly permits the collection of pressure data which theoretically can be reduced to yield vertical permeability values.

(4) Water-Quality Sampling and Water-Level Measurements

Selected wells on the Tract form a network which is sampled for water quality twice each year. This sampling is done with a swabbing unit for the deep aquifers and a submersible pump for the alluvial wells. Water-level measurements are taken once a month. Measurements are made with electronic sensing devices, steel tapes and continuous recording gauges.

b. Results and Interpretations

(1) Aquifer Characteristics (Hydraulics)

Four types of tests were conducted on the Tract to evaluate aquifer hydraulics. The mechanical procedures for tests were discussed under program description above. The results and interpretations of these tests are described below.

(a) Drilling and Jetting Tests

As part of the general well histories, a record was maintained of the water discharged during drilling. A representative portion of these data are presented on Figure IX-51. In general, three major water-producing zones are present beneath the Tract: 1) the interval immediately below the Four Senators; 2) A Groove; and 3) B Groove. In addition, a minor water-producing zone of local extent occurs at the Uinta-Parachute Creek contact. Production for the entire interval was always less than 800 gallons per minute (GPM), the maximum rate that the water could be lifted during drilling.

Because the entire hole was open during testing, the discharge and transmissivity information derived from the jetting is only qualitative. However, patterns can be noted in the changes in transmissivities with

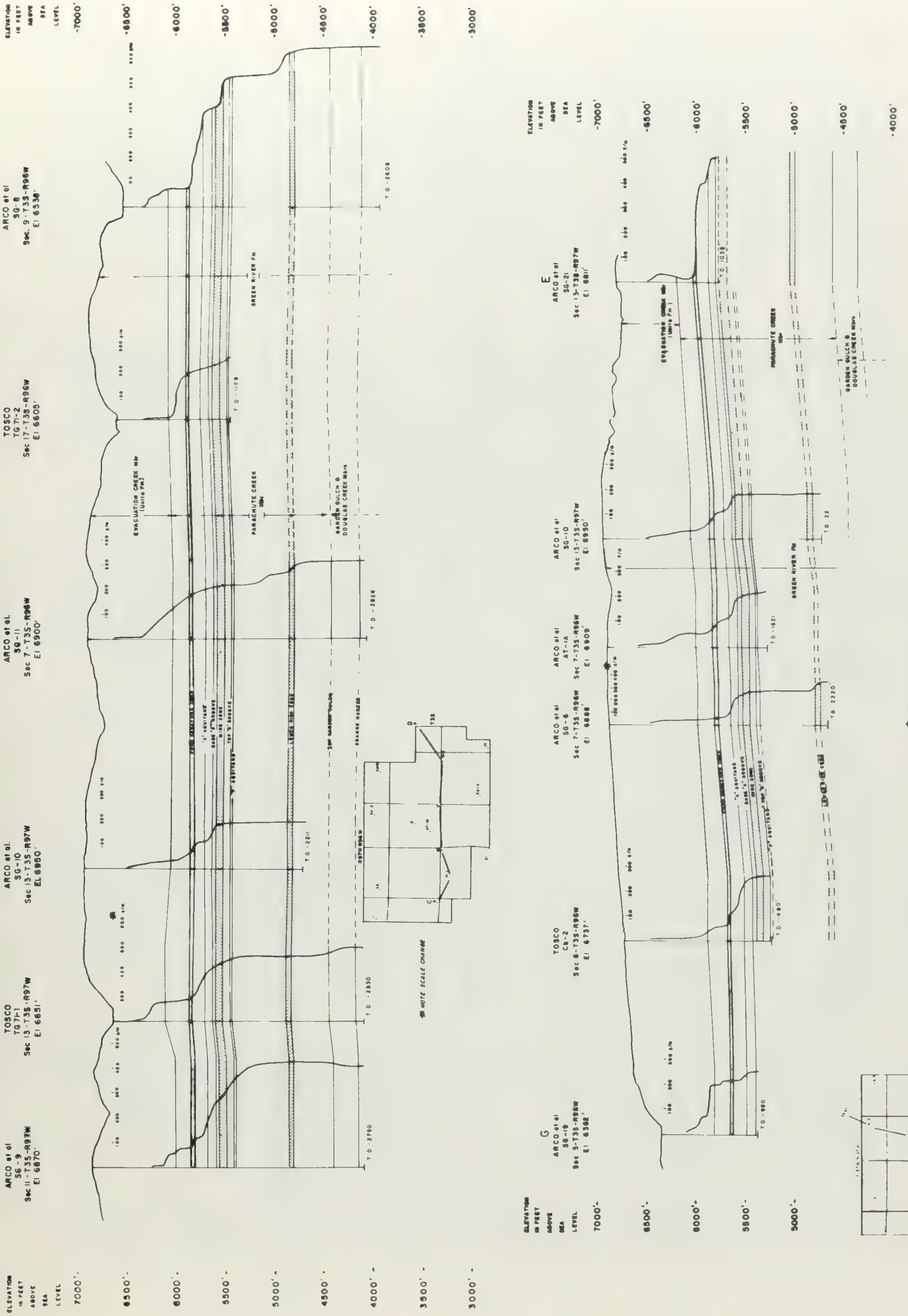


Figure IX–51 NORTH-SOUTH AND EAST-WEST STRATIGRAPHIC SECTIONS SHOWING WATER PRODUCTION CURVES (g/m), TRACT C-b

depth. Both discharge and transmissivity generally increase downhole, but because water could move laterally as well as vertically due to open hole conditions, some individual wells show a decrease in discharge and transmissivity with increased depth. No lateral patterns in discharge or transmissivity are readily discernible. As shown on Table IX-14, transmissivity calculated from the jetting test information is highly variable, ranging from 1.34 to 1350 ft^2/day for the several wells drilled on the Tract. The amount of water discharged during jetting was highly variable, ranging from 11 to 860 GPM.

(b) Pump Tests

The main aquifer tests were designed to obtain transmissivities and storage coefficients of the upper and lower aquifers and the leakance across the Mahogany zone. The data were analyzed using the equations for leaky artesian reservoirs from R. E. Glover's "Transient Groundwater Hydraulics" (1974). The results of the computations are summarized on Table IX-15. The upper main aquifer test data have good consistency. The close-in wells have very good curve fits to the data. The more distant wells approximate the type curve analysis reasonably well. Transmissivity of the upper aquifer ranges from 233 ft^2/day to 128 ft^2/day and arithmetically averages 168 ft^2/day. The storage coefficient in the upper aquifer averages 5.04×10^{-4} and varies from 1.68×10^{-3} to 6.92×10^{-5}. The greatest vertical leakance is 6.0×10^{-6} day^{-1} and the least is 4.25×10^{-7} day^{-1}. The average discharge of the pumped well over the drawdown period was 373 GPM. During the upper test, no drawdown was noted in the lower aquifer, which establishes that no vertical leakage occurred through the Mahogany zone during this test.

The analyses of the lower main aquifer drawdown test also show a good fit of the observation well data to the type curves. The transmissivity ranges from 14.7 ft^2/day to 91.9 ft^2/day. The arithmetic average transmissivity is 40.4 ft^2/day. The storage coefficient is generally only half as large as the upper aquifer with an average storage coefficient of 1.73×10^{4}. The storage coefficient ranges from 5.3×10^{-4} to 1.21×10^{-5}. The computed leakance values are in the same order of magnitude as in the upper aquifer, ranging from 3.93×10^{-7} to 1.96×10^{-5} day^{-1}. The average yield of the well during this test was 120 GPM. Linear data plots show that no water moved vertically downward through the Mahogany zone during the pumping of the lower aquifer.

During both main aquifer tests, significant anisotropic, nondirectional flow was noted. Well SG-11 was noted to drop much more rapidly than the two closer wells, SG-6 and SG-10. Computations analyzing the drawdown relationship, using R. E. Glover's equations for anisotropic analysis (unpublished equations being prepared for publication in 1976), derived a greatest-permeability direction for the upper aquifer as being in the east-northeast direction from the pumped well with a ratio of 9:1. Because of limited data, the analysis can only state in general that the direction of greatest permeability in the lower aquifer lies in a more north-south direction.

Table IX–14 WELL DATA FROM JET TESTING

Well No.	Depth of Test	Transmissivity ft^2/day	Conductivity Micromhos	Production gal./min.
Cb-1	1280	134	1820	178
	1480	167	2000	
	2100	195	3000	386
Cb-2	1280	668	2600	328
	1480	1203	2400	326
Cb-3	1240	869	2460	250
	1450	989	2400	300
	2122	1176	3040	350
Cb-4	1250	58.8	870	100
	1468	321	1010	230
SG-1	600	762	1000	610
	700	709	950	565
	1040	634	1000	467
	1105	820	1000	673
	2220	1158	2000	794
	2525	989	1900	840
SG-6	845	21.4	850	18
	1320	251	1250	189
	1440	330	1250	211
	1520	368	1300	211
	2220	439	1400	224
SG-8	600	334	1600	72
	970	540	1620	251
	1000	805	1600	251
	2115	1114	2400	494
	2608	1350	2600	458
SG-9	990	30.7	850	54
	1285	136	1200	282
	1360	179	1200	260
	2540	386	1100	274
	2750	310	1050	202
SG-10	960	23.5	–	21
	1330	398	850	148
	1430	402	900	167
	2211	1013	2100	152
SG-11	810	134	1180	112
	860	118	950	108
	1330	685	1005	176
	1390	566	1050	–
	1490	316	1200	108
	2465	752	2050	234
	2826	802	2250	148
SG-17	830	28.9	800	27
	1250	256	1400	103
	1330	284	–	153
	1622	271	1200	184
	2460	118	4400	162
SG-21	960	1.34	1100	11
	1036	660	600	292
TG-71-1	700	294	1140	200
	1040	802	9250	860
	2080	–	3300	–
	2150	–	1480	
	2260		2800	
	2300		3980	
	2400	–	2500	
	2530	450	2740	660
TG-71-2	630	–	760	
	720	–	1100	
	1000	628	–	
	1162	615	–	–

Table IX–15 RESULTS OF UPPER AQUIFER PUMP TESTS

Well Number (String #)	Transmissivity ft^2/day	Storage Coefficient	Leakance day–1
SG–10	233	4.21×10^{-4}	4.26×10^{-7}
AT–1A(#3)	159	4.23×10^{-4}	6.10×10^{-6}
SG–6	212	1.68×10^{-3}	1.27×10^{-6}
AT–1D(#3)	130	2.97×10^{-4}	8.05×10^{-7}
AT–1B	162	3.71×10^{-4}	1.56×10^{-6}
AT–1C	128	2.73×10^{-4}	1.23×10^{-6}
SG–11	155	6.92×10^{-5}	5.90×10^{-7}
		LOWER AQUIFER	
AT–1C(#2)	20.4	1.22×10^{-4}	1.96×10^{-5}
AT–1C(#1)	40.9	1.21×10^{-5}	3.93×10^{-7}
AT–1D(#1)	35.4	2.67×10^{-5}	8.77×10^{-7}
SC–6(#1)	91.9	5.30×10^{-4}	
AT–1D(#1)	43.8	4.19×10^{-4}	
SG–6(#2)	35.7	6.48×10^{-5}	3.44×10^{-6}
SG–10(#10)	14.7	3.92×10^{-5}	6.88×10^{-6}

The mini-pump tests were mainly designed to determine the extent to which thin, rich oil shale zones restrict vertical water flow. Using approximations of the aquitard thicknesses derived from geophysical logs, the computed leakance varies from 3.20 x 10^{-7} to 7.58 x 10^{-4} day^{-1}. The vertical hydraulic conductivities, using estimated aquitard thicknesses, ranges from 3.06 x 10^{-6} to 4.55 x 10^{-3} ft/day. From these analyses and those of the main aquifer tests, it can be seen that leakance and actual vertical permeabilities are very small. The transmissivities obtained from the mini-pump tests are also small, ranging from 1.71 ft^2/day to 18.4 ft^2/day. The storage coefficient is in the same order of magnitude as the main aquifer tests previously discussed, ranging from 2.08 x 10^{-4} to 1.20 x 10^{-3}. Results of the individual aquifer tests are summarized on Table IX-16.

The short-term pumping tests conducted in two alluvial wells near the Tract indicate transmissivity values of 1350 and 359 ft^2/day. Details of these analyses are available in the Summary Reports.

(c) Drill Stem Tests and Multi-packer Tests

Horizontal permeability values determined by drill stem tests and multi-packer tests are summarized in Table IX-17. The test results indicate that vertical permeabilities in this aquifer system are too low to be accurately determined by this testing procedure. The evaluation was done by computer, using oil-field analytical techniques and the data were reported in millidaries (md) rather than in usual hydrologic units. The greatest permeability is 300 md, the smallest was 1.6 md.

(2) Ground Water Quality and Potentiometric Surface

(a) Ground Water Quality

During the drilling of all the Tract wells, records were maintained of the variation of water conductivities with depth. These data were plotted on cross-sections to illustrate both the vertical and horizontal variability of water conductivities. Figure IX-52 shows two typical cross-sections. In general, the conductivity of the Uinta formation aquifer is between 1000 and 1800 micromhos (μmhos). The water of the Upper Parachute Creek member aquifer is indicated to be less saline than the Uinta formation waters. It is usually less than 1200 μmhos and commonly under 1000 μmhos. Below the Mahogany zone the conductivity increases again, but in this part of the section it generally remains less than 2000 μmhos. Below the R-4 zone, a 50-foot zone of extremely high conductivity water was encountered which had a total dissolved solids content exceeding 30,000 mg/l. On the average, conductivities of water produced during drilling below the R-4 zone were greater than 4000 μmhos.

Although samples taken during drilling show some vertical variation in electrical conductivity, samples taken at isolated zones from drill stem tests show much more dramatic differences in dissolved solids content. Figure IX-53 graphically illustrates the total dissolved

Table IX–16 RESULTS OF MINI PUMP TESTS

Test Number	Transmissivity ft^2/day	Storage Coefficient	Leakance day–1	Vertical Hydraulic Conductivity ft/day
Test #4	1.71	2.08×10^{-4}	3.20×10^{-7}	3.06×10^{-6}
Test #6	5.27	9.13×10^{-4}	7.58×10^{-4}	4.55×10^{-3}
Test #8	18.4	4.34×10^{-4}	1.84×10^{-5}	3.06×10^{-6}
Test #10	11.6	1.20×10^{-3}	4.63×10^{-5}	2.78×10^{-4}

Table IX–17 SG-17 DRILL STEM TESTS

DST No.	Interval, feet	Permeability, md.
1	386-436	N.D.
2	788-808	N.D.
3	822-869	11.0
4	866-919	12.7
5	919-970	34.0
6	967-1017	10.7
7	1017-1067	19.9
8	1066-1116	20.0
9	1116-1166	8.0
10	1164-1212	185.0
11	1200-1224	21.2
12	1215-1224	20.8
13	1224-1251	300.
14	1251-1271	8.0
15	1280-1309	13.0
16	1309-1336	N.D.
17	1327-1373	52.
18	1373-1419	15.
19	1423-1470	N.D.
20	1423-1470	23.9
21	1473-1522	3.0
22	1428-1522	4.7
23	1512-1572	4.0
24	1561-1572	23.0
24 (J)	1561-1622	N.D.
25	1618-1640	4.0
25 (J)	1618-1670	1.6
26	1668-1679	30.0
26 (J)	1668-1720	7.3
27	1711-1770	6.0
28	1768-1779	42.0
28 (J)	1768-1820	9.8
29	1818-1870	2.0
30	1869-1880	275.
30 (J)	1869-1910	30.
31	1918-1970	4.0
32	1966-2020	169.
33	2018-2070	N.D.
34	2120-2170	30.
35	2220-2270	N.D.
36A	2320-2370	N.D.
36B	2315-2370	N.D.
37	2395-2460	35.

(J) – Jetting Test

SG-17 MULTI-PACKER TESTS

MPT No.	Interval, feet	Permeability md.
1	1089-1114	75
2	1123-1148	N.D.
3	1147-1172	92
4	1184-1209	N.D.
5	1338-1363	N.D.
6	1422-1447	N.D.

N.D. – No data obtained due to equipment malfunction, analytical problems, no water injection, packer leakage, etc.

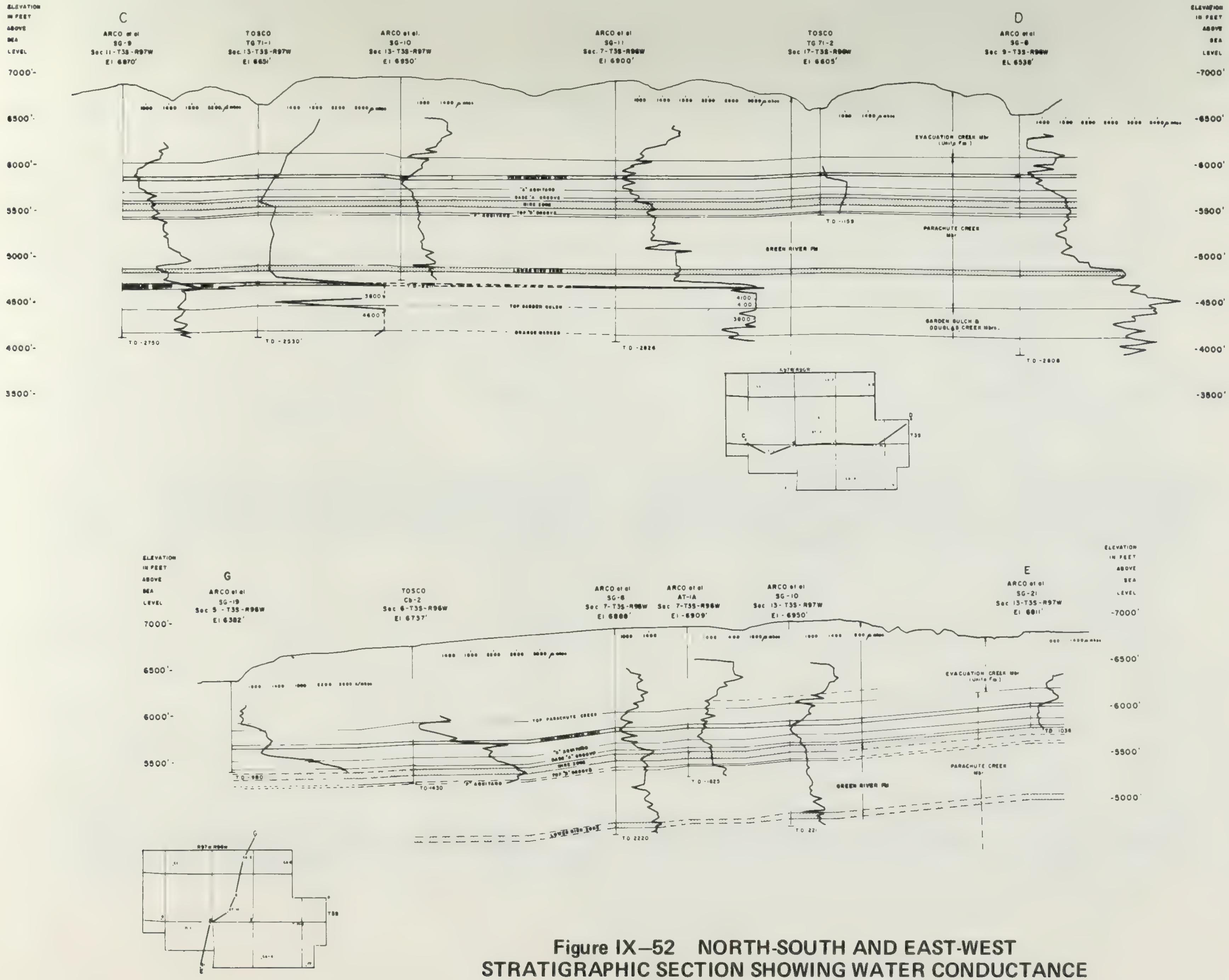


Figure IX–52 NORTH-SOUTH AND EAST-WEST STRATIGRAPHIC SECTION SHOWING WATER CONDUCTANCE CURVES (micromhos), TRACT C-b

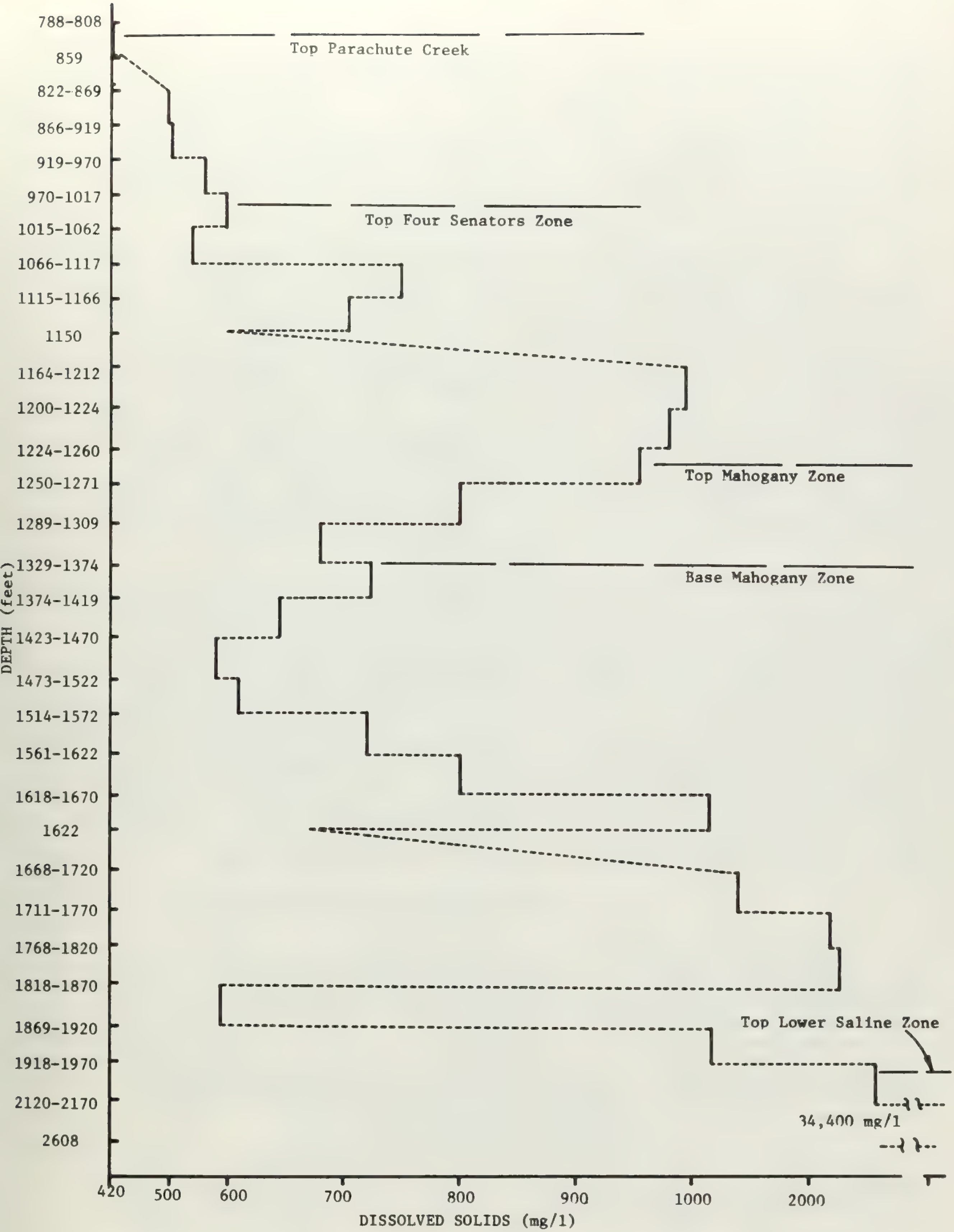


Figure IX–53 TOTAL DISSOLVED SOLID CONTENT OF DRILL STEM TEST WATER FROM SG-17

solids resulting from analyses of the drill stem tests on SG-17. The major zones of obvious chemical difference are: 1) the section above the Four Senators zone; 2) the interval between the Four Senators and the top of the Mahogany zone; 3) the upper part of the lower aquifer; 4) the lower aquifer above the R-4 zone; and 5) the high saline zone below the R-4 zone. Within each major zone the dissolved solid content fluctuates over a range of several hundred mg/l.

Water-quality samples are being obtained from all wells twice a year. Three sampling runs have been completed. Figures IX-54 and IX-55 show the perforated intervals for wells completed in the upper and lower aquifer, respectively. Water-quality (Stiff) diagrams have been constructed for all wells depicting the relative concentrations of major constituents. Figure IX-56 shows Stiff diagrams for representative wells for the alluvial, upper and lower aquifers. Characteristic shapes for each well remain relatively constant in spite of the fact that the wells are perforated over a wide interval. The water in the upper aquifer system is generally a mixed sodium sulfate-sodium bicarbonate type. Below the Four Senators zone, the sodium content increases and the water changes to a sodium bicarbonate type. Below the Mahogany zone, the dissolved solids content is almost entirely sodium bicarbonate.

Measurable quantities of a wide variety of trace elements are found in the deep wells. Table IX-18 lists the average values obtained during the spring 1975 sampling. The average values listed are based on all deep (non-alluvial) wells sampled, with the exception of SG-11, which was perforated in the extremely saline deep zone, and SG-10, which had been affected by an acid treatment. For comparison, the recommended maximum values for various uses ("Proposed Criteria for Water Quality", EPA, 1973) are also listed in the table. Fluorine is the only element which occurs in greatly excessive concentration, with an average level almost 10 times the acceptable value for most uses. Barium, boron, manganese and lead occur at levels near the recommended maximum limits. It can be concluded that the ground water encountered above the R-4 zone on the Tract could be made acceptable for most uses, if defluoridated.

(b) Potentiometric Surface (Water Levels)

Two potentiometric maps have been constructed for the upper and lower aquifers as defined by the USGS (Figures IX-57 and IX-58). These are based on water-level measurements from wells completed only in the individually mapped aquifers. The hydrostatic head difference between the two aquifers varies from a measured low of +5 feet in the northwest corner of the Tract (SG-1) to a high of +69 feet in the north-central part of the Tract (SG-6). Throughout the Tract, the upper aquifer always has a higher head than the lower aqufier.

The contour of the potentiometric surface of the upper and lower aquifers generally follows the same pattern as the regional structure. The surface slopes to the north with a gradient varying between 125 and 175 feet per mile. The uniform nature of the contours indicates that,

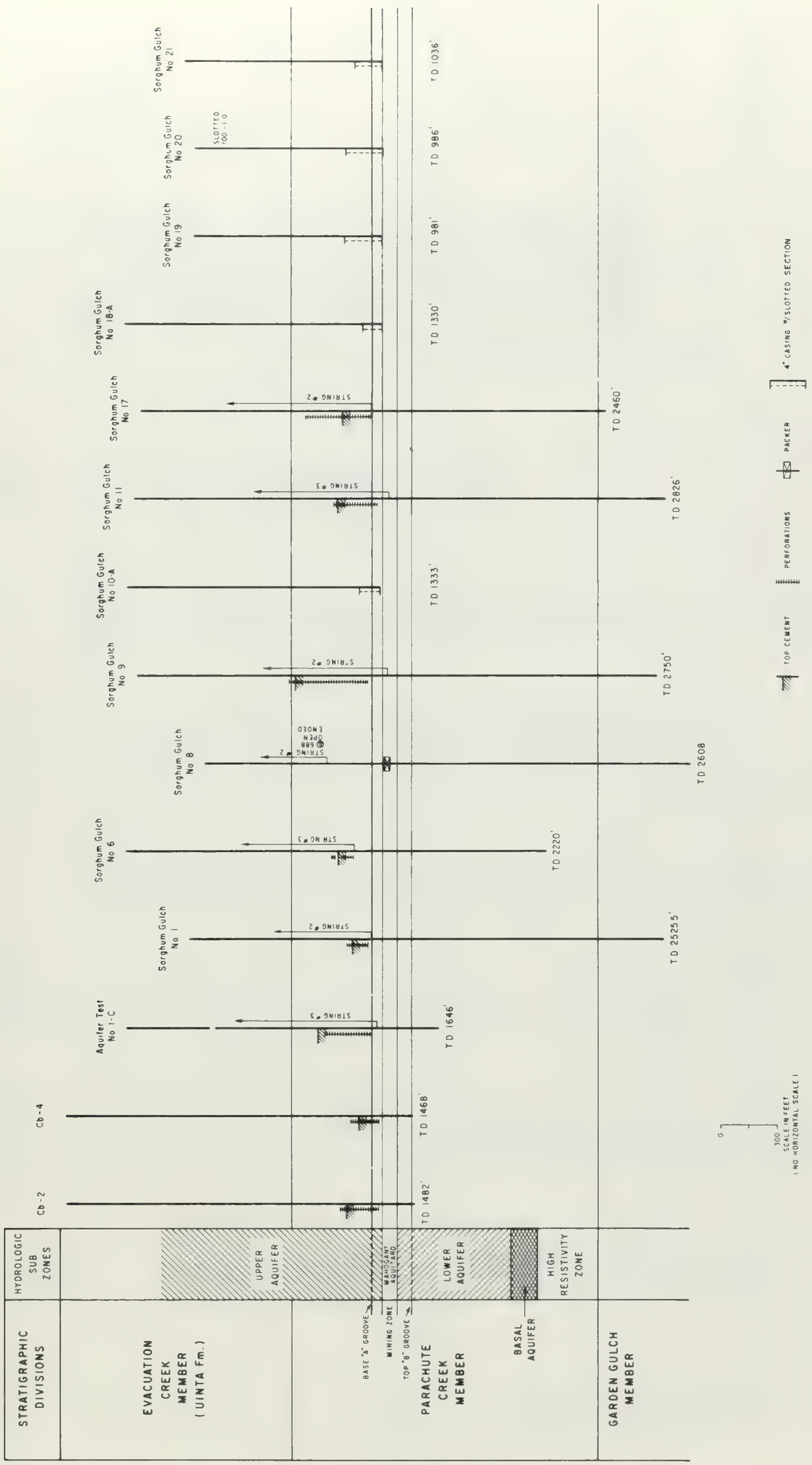


Figure IX—54 WELL PERFORATIONS IN THE UPPER AQUIFER TRACT C-b

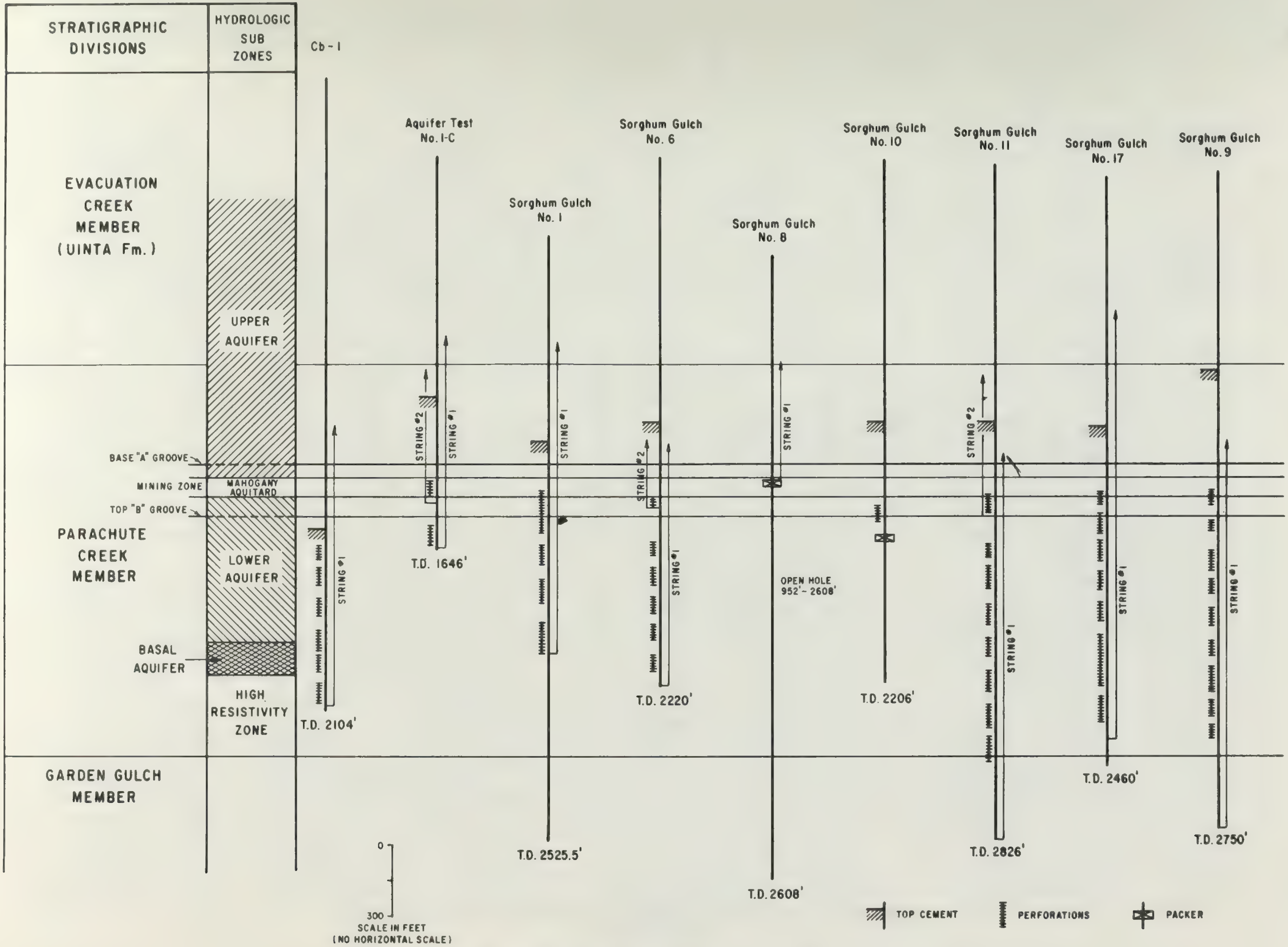


Figure IX—55 WELL PERFORATIONS IN THE LOWER AQUIFER TRACT C-b

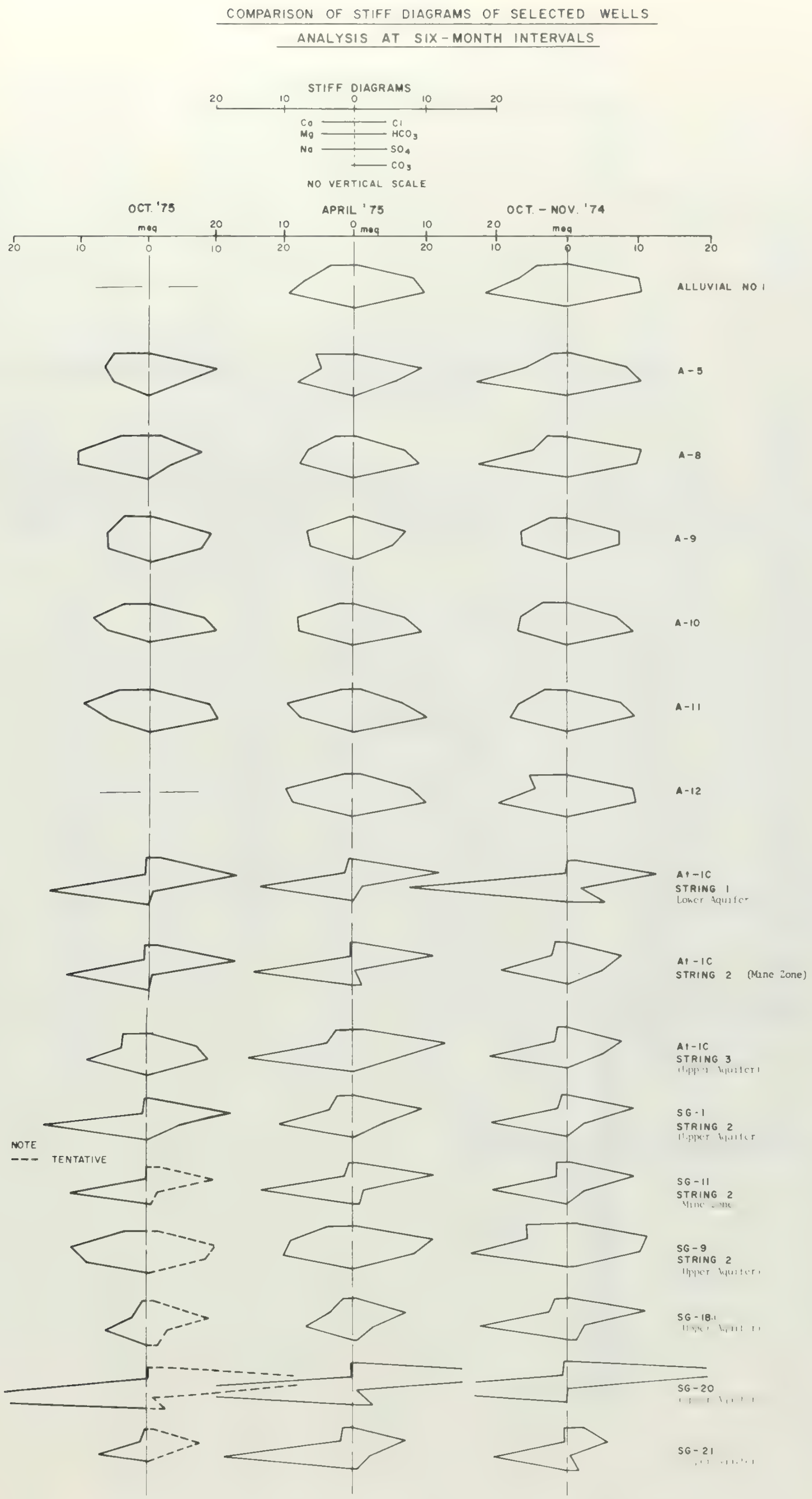


Figure IX–56 WATER QUALITY (Stiff) DIAGRAMS OF SELECTED WELLS, TRACT C-b AREA

Table IX–18 TRACE ELEMENTS IN GROUND WATER
ALL VALUES IN mg/l

Constituent	*Mean Value Observed in C-b Wells, Spring 1975	Recommended Maximum Values ("Proposed Criteria for Water Quality" – EPA, 1973)			
		Agriculture (Irrigation)	Agriculture (Irrigation-20 years)	Agriculture (Livestock)	Freshwater (Public Supply)
Aluminum	0.2	5.0	20	5.0	--
Arsenic	0.03	0.1	2.0	0.2	0.1
Barium	0.8	--	--	--	1.0
Beryllium	0.001	0.1	0.5	--	--
Boron	1.6	0.75 to 2.0	--	5.0	1.0
Cadmium	.002	0.01	0.05	0.05	0.01
Chromium	< 0.01	0.1	1.0	1.0	0.05
Cobalt	0.004	0.05	5.0	1.0	--
Copper	0.03	0.2	5.0	0.5	1.0
Fluorine	16	2.0	15.0	2.0	--
Iron	< 0.05	5.0	20.0	--	0.3
Lead	0.05	5.0	10.0	0.1	0.05
Manganese	0.07	0.2	10.0	--	0.05
Mercury	< .001	--	--	1.0	0.002
Nickel	0.03	0.2	2.0	--	--
Selenium	0.005	0.02	--	0.05	0.01
Vanadium	0.02	--	--	0.1	--
Zinc	0.06	--	--	25	5

* excluding deep strings of SG-10 and SG-11

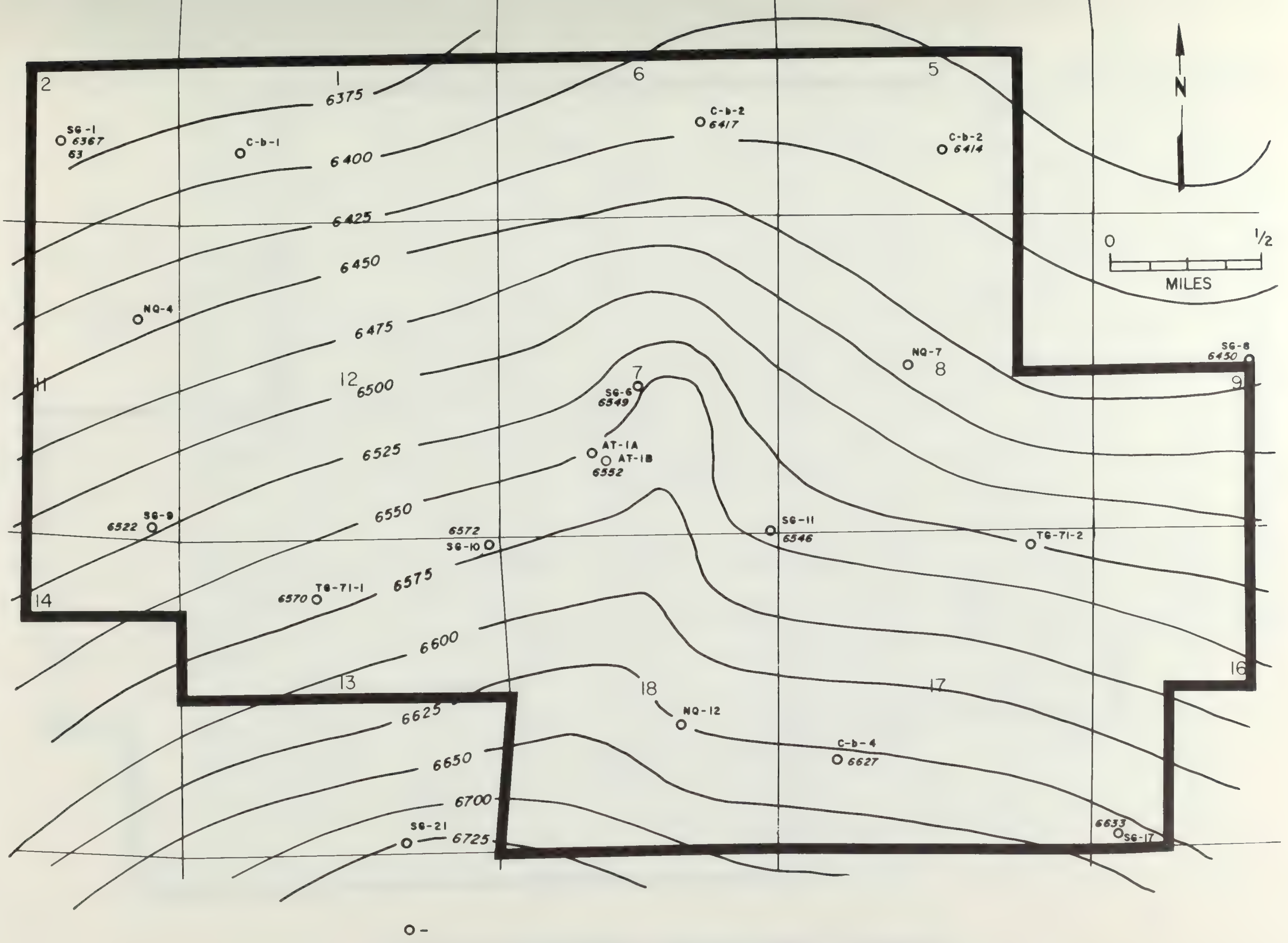


Figure IX–57 PRELIMINARY POTENTIOMETRIC SURFACE UPPER AQUIFER, JUNE 1975

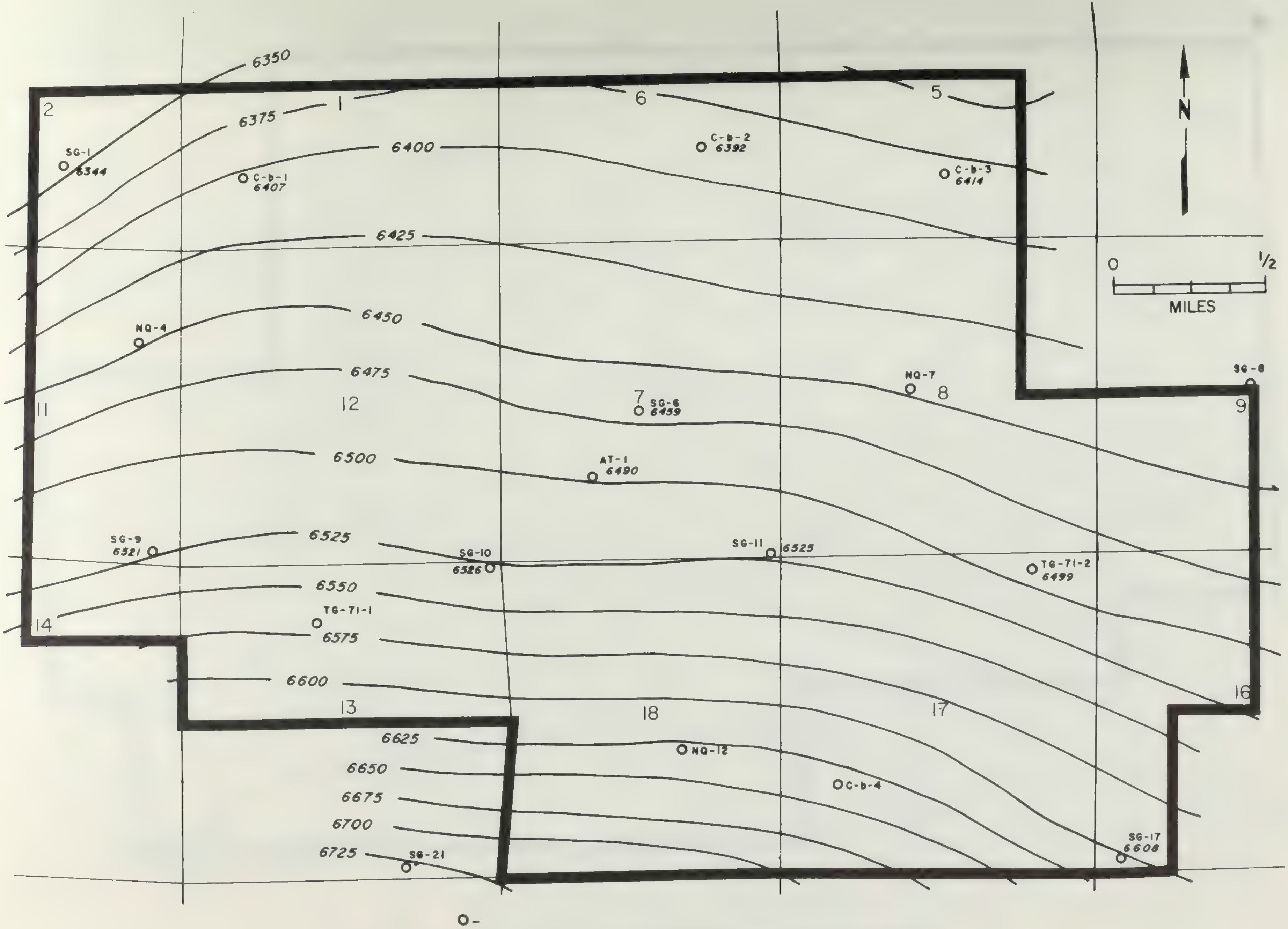


Figure IX–58 PRELIMINARY POTENTIOMETRIC SURFACE LOWER AQUIFER, JUNE 1975

in general, the hydraulic gradient is relatively uniform across the Tract. The main aquifer tests, however, demonstrated a strong anisotropic nature in flow to wells.

c. Conclusion

Analysis of the extensive aquifer tests conducted on the Tract has served to establish a better definition of the Tract geohydrology. The resulting aquifer model varies from the USGS regional model. The principal points of difference are: 1) the degree of vertical communication both between and within the major aquifers; 2) the measured transmissivities; and 3) the measured storage coefficients.

These tests have established the presence of two major zones of low permeability. The Four Senators zone and the Mahogany zone both restrict vertical flow, as evidenced by distinct differences in water chemistry and direct leakance measurements. As a result, it is possible to define three major bedrock aquifers beneath the Tract. These are: 1) the Uinta formation and upper Parachute Creek member above the Four Senators zone; 2) the upper Parachute Creek member below the Four Senators zone; and 3) the lower Parachute Creek member between the Mahogany zone and R-4 zone. The high salinity zone and the Douglas Creek-Garden Gulch system are considered to be separate minor aquifers.

In addition to the two major aquitards, thin, rich oil shale layers within the main oil shale zones further inhibit vertical movement of water. The main aquifer and mini-pump tests results indicate that vertical leakance in the upper and lower aquifers is 1 to 2 orders of magnitude smaller than USGS regional values.

Comparison of C-b data with the USGS report shows that both transmissivities and storage coefficients of the aquifer systems on the Tract are considerably smaller than those used by USGS to represent the basin. Transmissivity values for the upper aquifer system beneath the Tract range from 155 to 233 ft^2/day, while USGS values in the area range from 60 to 870 ft^2/day. The lower aquifer system on the Tract was found to have transmissivities approximately one-half those determined by the USGS for the area.

Based on the information derived from the hydrologic testing program, it appears that mine dewatering will be a considerably smaller problem than originally anticipated. Because the rock was found to have smaller transmissivities and storage coefficients than predicted, less water will infiltrate into the mine area than initially projected. Moreover, it now appears that a limited stratigraphic interval adjacent to the mine zone can be successfully dewatered without disturbing the

overlying and underlying aquifers. This means that if shafts and wells are properly sealed, the dewatering operation will have little effect, if any, on springs and seeps in the vicinity of the Tract.

Computer modeling is in progress to quantify the effects of shaft dewatering on the hydrologic regime. Preliminary results from this program indicate a peak inflow of only 3.7 ft^3/sec for the mine shaft and development mine. Additional modeling of the mine dewatering requirements will be undertaken as further information becomes available.

X. CLIMATE AND AIR QUALITY

A. Regional Setting

The climate of the Piceance Creek basin can be classified as arid steppe (or semi-arid) and is characterized by abundant sunshine, generally low precipitation, warm summer temperatures, low relative humidity and cool nights. In midwinter, air temperatures are often low, but strong solar radiation and the dry air combine to provide a generally pleasant environment.

The local climate is strongly influenced by microclimatic features such as slope, aspect, elevation, soil type, soil moisture content and vegetation. The local surface wind patterns and vertical temperature profiles are almost entirely dependent upon topography.

Annual precipitation varies from approximately 12 inches in the extreme northwest corner of the basin to approximately 24 inches in the southwest corner. During the months from December to April, slightly less than half of the precipitation occurs as snow. The snow provides a large source of runoff as snowmelt in the spring. Normally, little precipitation falls in the spring. During the later part of the summer, precipitation may occur as high-intensity thunderstorms, with accompanying flash floods. These storms occur throughout the region an average of eight or nine days per month, based on July and August data from the National Weather Service station in Grand Junction. Fall weather is dry and mild with occasional rain or snow storms.

Temperatures are generally moderate during spring, summer and fall, with some thermal extremes. Maximum temperatures in the lower elevations can reach 100°F in midsummer, while winter temperatures can drop to as low as minus 50°F. The number of frost-free days varies from 50 days in the higher elevations to 125 days in the lower elevations. The dry climate and relatively short growing season have a limiting effect on agricultural use of the land, which has been restricted to growth of small amounts of irrigated hay and alfalfa, some corn, and small grains along Piceance Creek and Yellow Creek.

The relative humidity is generally moderate, and the duration of sunshine is long. The average annual percentage of available sunshine at Grand Junction exceeds 75%. A relatively high evaporation rate exists at the lower elevations throughout the region. As an example, the evaporation rate at Grand Junction has been measured at 90 inches per year.

Topography strongly influences local wind circulation and the dynamics which govern the transport and diffusion of air contaminants. The two main effects of topography are well-developed valley wind patterns and a frictional effect induced by the mountains.

Valley wind patterns follow diurnal, or daily, variations. Gen-

erally wind velocities are lowest about dawn when there is little vertical thermal mixing of air, and are greatest in the early afternoon when, due to the heating of the earth's surface by the sun, vertical mixing of air is highest. During warm afternoons, the heated air expands and moves up the valley because of the lateral restrictions imposed by the topography of the valley. This is known as a valley wind. These generally light winds flow along the main valley and develop as upslope winds, and are due to greater heating of the valley sides than of the floor. At night, the cold, dense air at higher elevations moves into the valley and causes a downslope wind.

Mountains and rough terrain can significantly modify the flow of upper-level air because of frictional effects. In those valleys with broad floors, inversions usually form at night. There is minimal air movement beneath these inversions and thus the wind direction will be determined by the local downslope circulation. These inversions are usually dissipated by surface heating during the day, but may persist for portions of the day. During winter, one major factor in enhancement and persistence of these inversions is the amount of snow cover and its level of reflectance. If snow cover is present, the incoming solar radiation is reflected during the day. At night, the snow, because it does not conduct heat very well, allows little heat to come up from the ground to replace the atmospheric heat lost due to radiation. As a result, the downslope flow is enhanced. And because snow reflects incoming radiation during the day, the upslope flow is retarded and inversions will tend to persist.

B. Program Description

The Tract climate and air quality programs are designed to satisfy the following objectives:

- to establish the air quality and meteorological baseline;
- to become an integral part of the long term monitoring program and to establish the basis for that program and aid in determining its scope, objectives and design;
- to provide data that will allow a valid assessment and prediction of any potential air quality impacts and establish a basis for mitigating these impacts;
- to provide environmentally oriented criteria for shale oil plant design and location, such as peak wind speeds and the presence of temperature inversions.

The air quality-meteorology monitoring network is shown in Figure X-1. It consists of: 1) five air quality stations (housed in trailers) for determining ambient levels of gaseous constituents and reporting the supporting

meteorological data; 2) three mechanical weather stations for measurement of surface winds and temperatures; 3) a 200-foot meteorological tower to determine low-altitude vertical profiles of wind, temperature and relative humidity; 4) two acoustic sounders for measuring atmospheric inversions; and 5) one location for measuring area-wide visibility. The five air quality stations are:

Station No.	Description
020	Downwind of the proposed plant site in Piceance Creek valley at the Redd Ranch (off-tract)
021	In Piceance Creek valley at Rock School, downstream and generally downwind of Station 020 (off-tract)
022	In Piceance Creek valley at the Gerald Oldland Ranch, upstream and generally upwind of Station 020 (off-tract)
023	On the Tract near location of the proposed plant site which is the present location of a 200-foot meteorological tower.
024	On the Tract near a predicted point of maximum concentrations downwind of the proposed plant site.

The prevailing winds from the south and southwest were used to help determine the location of Station 024 downwind of the proposed plant site. The location of the predicted point of estimated maximum concentrations is less precise, since it ultimately will depend on actual plant stack characteristics, wind conditions and atmospheric stability. A diffusion model will be used to help predict the point more accurately (See Section V. A.).

The topography of the Piceance Creek valley constrains the air mass within the valley and causes the formation of upslope (or upstream) flow of air during the day and downslope (or downstream) flow of air at night. This upstream and downstream flow in the Piceance Creek valley is monitored by Stations 020, 021 and 022. Turbulence caused by the roughness of the topography and solar radiation also must be considered, but these effects are more difficult to predict. Meteorological data taken at the five trailers and three weather stations helps create a better understanding of the complex wind patterns near the surface.

A detailed description of the air quality and meteorology program, including the parameters measured and sampling frequencies, is given in Tables X-1 and X-2. Sulfur dioxide, hydrogen sulfide, and suspended particulates are monitored at all stations. In addition, hydrocarbons, methane, oxides of nitrogen, ozone and carbon monoxide are monitored at Stations 020 and 023. Wind speed and direction are taken at a 30-foot

Table X–1 AIR QUALITY & METEOROLOGY DATA DESCRIPTION

Symbols represent sampling frequency on next table

Category & Location / Measurement	SO_2	H_2S	Particulates	Total Hydrocarbons	Methane (CH_4)	Non-CH_4 H.C.(1)	Ozone	NO_x	NO	NO_2(2)	CO	Horizontal Wind Speed	Horizontal(3) Wind Direction	Bivane Wind Speed	Bivane Horizontal(3) Wind Direction	Bivane Vertical(3) Wind Direction	Relative Humidity	Air Temperature	Precipitation	Barometric Pressure	Solar Radiation	Temperature Difference	Acoustic Echo	Visibility
Air Quality & Surface Meteorology																								
Trailer 020	X	X	0	Y	Y	Y	X	X	X	X	Y	X	X				X	X	X					
021	X	X	0									X	X				X	X	X					
022	X	X	0									X	X				X	X	X					
023	X	X	0	Y	Y	Y	X	X	X	X	Y	X	X				X	X	X	X	X			
024	X	X	0									X	X				X	X	X	X				
Mechanical Weather Station																								
MRI 1												Z	Z					Z						
2												Z	Z					Z						
3												Z	Z					Z						
Low Altitude Meteorology																								
@ Met. Tower Ground Level																								
8 - Ft.												X	X				X	X						
30 - Ft.												X	X	X	X	X	X	X				1,2		
100 - Ft.												X	X	X	X	X	X	X				1		
200 - Ft.												X	X	X	X	X	X	X				2		
Upper Air Studies																								
@ Met. Tower 200 - 6000 Ft.												*	*					*						
Temperature Inversions																								
@ Met. Tower																							-3-	
@ Trailer 021																							-3-	
Visibility																								
@ Hunter Creek																								#

(1)Obtained by Subtraction: THC - CH_4

(2)Obtained by Subtraction: NO_x - NO

(3)Std. deviation is calculated here also

Table X–2 AIR QUALITY & METEOROLOGY SAMPLING FREQUENCY & MIN. AVERAGING TIMES

Symbols appear on previous table

Symbol	Sampling Frequency	Min. Average Time or Report Frequency	Description
X	1/sec	5 min. average	AQ & low alt. met.
Y	5 min. average	5 min. average	
Z	Continuous	Hourly average	
0(1)	1/24 hr. span	(1) Daily Every 6th day Quarterly Quarterly Quarterly	(1) Particulates Trace elem. composites Gross radioactivity Part. size distribution Volatile metals
1	1/sec	5 min. average	Temp. difference between 30' and 100' height on met. tower
2	1/sec	5 min. average	Temp. difference between 30' and 200' height on met. tower
*	at least 2/day for 15 days/ quarter	same	High alt. meteorology temp. and wind profiles to 6000 ft.
ɛ	1/(14-sec)	Onset & Extent of Inversions	Acoustic echo (for Temp. Inversions)
#	7 times per day every 6th day	same	Area-wide visibility via photographic photometry

(1) Particulate samples of 24-hour duration are obtained from Hi-Vol samples utilizing fiberglass filters. Every sixth day a 24-hour particulate sample on a cellulose filter is obtained. The quarterly composites of these filters are screened for trace elements and radioactivity. In addition, volatile trace metals are collected and analyzed by special techniques.

level at each station. Relative humidity, temperature and precipitation are also measured at each station, while barometric pressure is taken at two stations and solar radiation at one station. In addition, three mechanical weather stations provide wind speed, wind direction and temperature at hourly intervals. These are at the auxiliary locations shown on Figure X-1.

The complex near-surface wind patterns vary with elevation above the surface. To assess this vertical variation, a 200-foot meteorological tower has been installed at Station 023, as shown in Figure X-1. As indicated in Table X-1, low altitude meteorological data are obtained on the meteorological tower at four levels (at 8, 30, 100 and 200 feet). These data consist of wind direction and speed, relative humidity and temperature. Temperature differences are obtained between the 30-foot and 100-foot levels and 30-foot and 200-foot levels as part of an integrated approach toward determination of atmospheric stability. Basic data include diurnal variations (hourly averages) at the four elevations for wind speed, wind direction (as a vector average), relative humidity and temperature. Bivane wind speed and horizontal and vertical components of direction are measured at the 30-foot, 100-foot and 200-foot levels.

Upper air studies were conducted to obtain vertical profiles of wind and temperature near the meteorological tower up to approximately 6000 feet above the surface. Wind data are obtained from pilot balloon (pibal) releases at the meteorological tower. Vertical temperature profiles are obtained by an instrumented aircraft flying in ascending and descending spirals. A knowledge of the variation in the temperature at increasing altitudes (called the lapse rate) helps determine the atmospheric stability. If the actual lapse rate is less than the dry adiabatic lapse rate (DALR) then the atmosphere is said to be stable and the vertical diffusion of gaseous constitutents is inhibited. If the actual lapse rate is greater than the DALR then the atmosphere is said to be unstable and diffusion proceeds freely in both the horizontal and vertical directions. When the air temperature increases with height an inversion is said to be present. Inversions can develop into a layer of extremely stable air and inhibit dispersion of gaseous constituents.

Two acoustic sounders have also been installed both on the Tract (at the meteorological tower) and in Piceance Creek valley (at Station 021). These sounders measure inversion heights continuously by emitting an audio pulse every 14 seconds and measuring the time for a return echo. If pronounced layers of either stable or unstable air exist, the pulse bounces off the layers. The time of travel is used to compute the height to the top of the layer. The specific "signature" (recorded pattern) indicates stability or unstability.

A joint visibility study with the Rio Blanco Oil Shale Project (Tract C-a) was started in October, 1975. The visual range in miles is to be measured every sixth day during a one year period at the Hunter Creek ridge site, a point about midway between Tracts C-a and C-b (See Figure X-1).

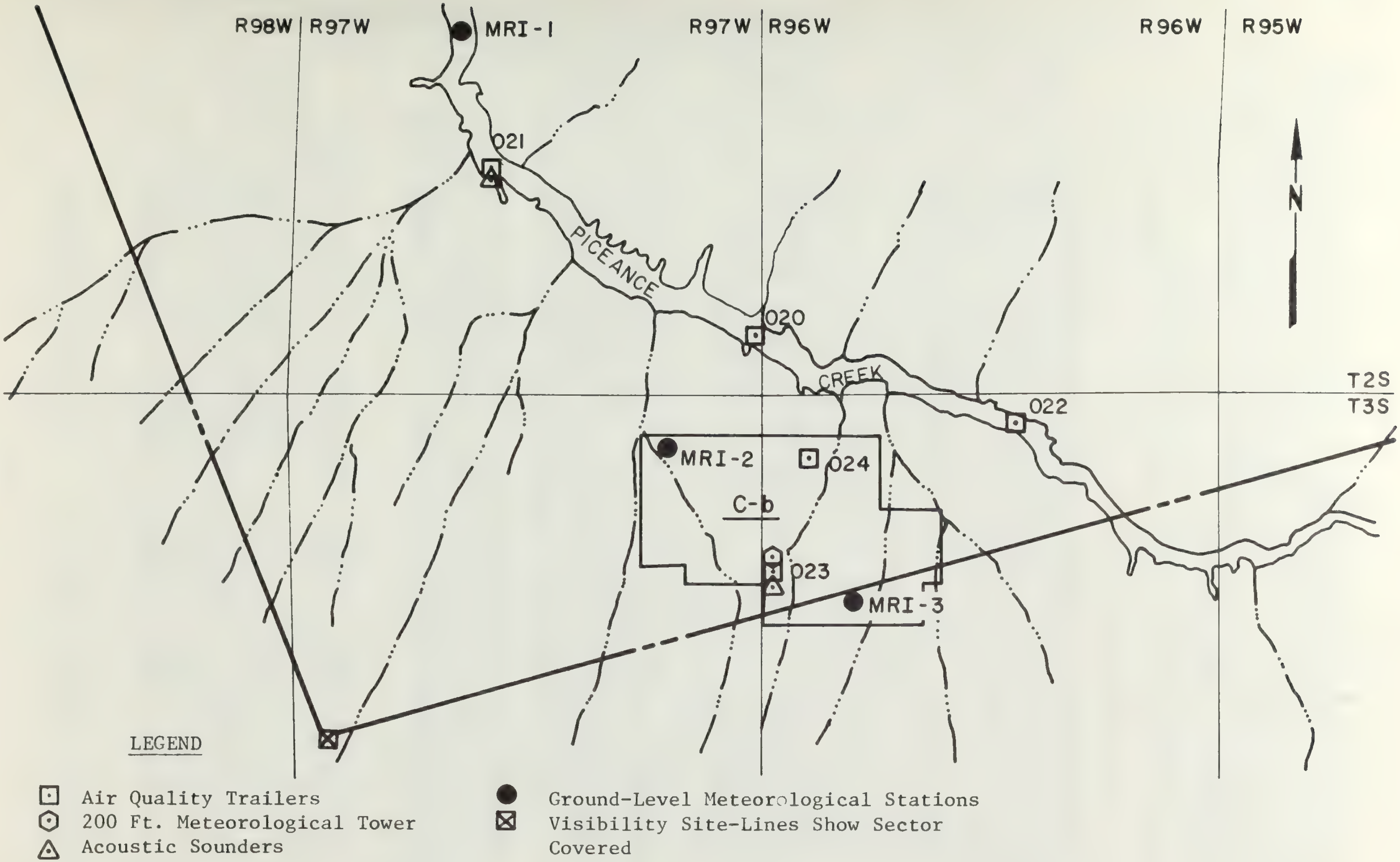


Figure X–1 AIR QUALITY AND METEOROLOGICAL STATION LOCATIONS

Each measurement includes photographs of designated objects in each of four viewing directions covering an approximate 90° north-to-east sector. Each view is photographed at specified times during the day with both black and white and color film. The contrast between the object image and the background sky as determined from the film negative is used to compute the visual range in miles.

C. Results and Discussion

1. Meteorology

The meteorological summary for temperature and relative humidity is presented in Table X-3. The maximum hourly temperature measured was 90°F in June and July, 1975. A minimum hourly temperature of minus 51°F was measured in January 1975 in Piceance Creek valley at Rock School (Station 021). The minimum temperature measured concurrently on the plateau at the meteorological tower was minus 5°F. This gives an indication of the strength of drainage flows of cold air into Piceance Creek valley during the winter. In general, temperatures in the winter in Piceance Creek valley are colder than temperatures on the plateau.

Relative humidity (Table X-3) has ranged from 8% to 100%. Hourly averages vary from 72% on the plateau to 75% in the Piceance Creek valley during the winter; in the summer these two averages decrease to 29% and 39%, respectively. The annual average is generally higher in the Piceance Creek valley than on the plateau. This is consistent with cooler average temperatures in the valley.

Precipitation data are summarized in Table X-4. Generally, precipitation data at the air quality stations have been lighter than at stream gauging and microenvironmental stations. The reasons for this anomaly are under investigation. The maximum monthly precipitation to date was 1.2 inches recorded in May 1975. There is generally more precipitation at the plateau stations than at the Piceance Creek valley stations.

The maximum wind speed (Table X-5) measured over a 5-minute period was 56 mph on the plateau in April 1975. Gusts during this period reached 79 mph. Hourly average wind speeds have ranged from 3 mph to 10 mph, and are generally higher on the plateau than in Piceance Creek valley.

Winds are generally directed downslope, downvalley at night and upslope, upvalley during the day. A summary of the vector monthly averages for winds is given in Table X-6. This table gives the average wind speed and direction for each station, thus indicating the dominant or prevailing winds at that station. The persistence of winds in a particular direction in Piceance Creek valley is important. It indicates whether the entrained air mass flows long enough in a particular direction to disperse pollutants (as opposed to air moving up-valley and down-valley without achieving any significant dispersion). Using

Table X–3 METEOROLOGICAL SUMMARY: TEMPERATURE AND RELATIVE HUMIDITY
1974-1975

Trailer	Item	Month												Annual
		Nov.	Dec.	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	
020	Temperature, Hourly Max. (^{o}F)	50	45	50	47	59	69	78	87	89	88	83	77	89
021		52	46	53	49	57	68	78	88	90	90	83	79	90
022		53	47	53	47	55	68	77	78	87	89	83	78	89
023		48	49	43	42	50	68	71	83	84	82	78	71	84
024		—	37	51	47	55	62	77	87	90	90	83	74	90
020	Temperature, Hourly Min. (^{o}F)	-14	-30	-46	-24	-28	-19	15	30	42	29	17	0	-46
021		-17	-34	-51	-29	-28	-21	16	25	37	29	14	-1	-51
022		0	-22	-38	-22	-23	-15	14	31	45	32	19	2	-38
023		5	0	-5	0	-6	6	22	34	51	40	29	14	-6
024		—	-8	-29	-10	-18	-5	28	32	51	38	24	9	-29
020	Temperature, Hourly Avg. (^{o}F)	27	13	15	19	32	36	48	58	67	63	53	42	39
021		27	11	15	20	30	35	47	56	67	63	53	40	39
		29	15	18	21	30	36	48	56	68	64	55	45	40
		32	25	23	24	31	35	46	56	67	65	56	47	42
		—	15	22	24	32	38	49	61	71	69	58	45	44
020	Rel. Hum., Hrly Max. (%)	100	100	96	98	100	99	100	98	99	99	98	100	100
021		85	95	100	100	100	100	100	100	100	100	100	100	100
022		100	100	100	100	100	100	100	100	90	100	100	100	100
023		100	100	100	100	100	100	100	100	100	87	93	100	100
024		100	100	100	100	100	100	100	95	96	94	99	100	100
020	Rel. Hum., Hrly Min. (%)	22	23	24	22	23	15	12	9	10	12	13	13	9
021		19	22	26	29	30	22	12	8	10	11	15	15	8
022		26	27	30	27	28	19	17	19	21	16	17	17	16
023		24	25	26	32	37	32	28	25	28	12	16	15	12
024		25	25	26	26	28	16	16	11	12	15	16	16	11
020	Rel. Hum., Hrly Avg. (%)	66	72	66	65	64	56	54	47	49	39	41	46	55
021		63	74	75	73	70	65	58	53	56	43	49	55	61
022		70	74	71	71	70	61	58	59	57	44	45	49	61
023		63	69	68	72	72	67	64	54	54	29	35	40	57
024		62	69	65	66	66	55	51	38	45	34	38	41	53

Table X–4 METEOROLOGICAL SUMMARY: PRECIPITATION

1974-1975

Trailer	Item	Month												Annual
		Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	
020	Precip.,			0.02		0.02	0.02	0.03	.08	.03	0.16	0.03	0.02	0.16
021	5-Min. Max. (Inches)			0.02	0.02	0.01	0.01	0.12	.17	.09	0	0.02	0.02	0.17
022			0.01	0.03	0.01	0.04	0.02	0.03	.05	.13	0.13	0.02	0.03	0.13
023				0.04	0.01	0.02	0.03	0.05	.09	.20	0.04	0.04	0.02	0.20
024			0.01	0.01	0.01	0.02	0.03	0.03	.02	–	0	0.01	0.03	0.03
020	Precip.,			0.05	0	0.08	0.05	0.08	.10	.09	0.29	0.05	0.11	0.29
021	1-Hr. Max. (Inches)			0.04	0.02	0.06	0.03	0.18	.36	.11	0	0.05	0.16	0.36
022				0.05	0.02	0.07	0.10	0.12	.05	.33	0.47	0.02	0.09	0.47
023				0.08	0.01	0.08	0.13	0.16	.14	.33	0.05	0.16	0.03	0.33
024			0.01	0.03	0.03	0.07	0.10	0.06	.03	0	0	0.01	0.08	0.10
020	Precip.,			0.14	0	0.13	0.15	0.10	0.23	0.28	0.35	0.05	0.31	0.35
021	24-Hr. Max. (Inches)			0.13	0.02	0.28	0.10	0.18	0.46	0.25	0	0.06	0.33	0.46
022				0.17	0.05	0.09	0.18	0.20	0.07	0.33	0.64	0.03	0.12	0.64
023				0.14	0.04	0.17	0.22	0.41	0.19	0.34	0.06	0.16	0.05	0.41
024			0.01	0.15	0.08	0.34	0.23	0.17	0.04	0	0	0.01	0.24	0.34
020	Precip.,			0.18	0	0.31	0.32	0.25	.28	.41	0.44	0.05	0.83	3.07
021	Monthly Tot. (Inches)			0.25	0.04	0.45	0.20	0.51	.73	.30	0	0.06	0.54	3.08
022			0.02	0.20	0.08	0.38	0.42	0.54	.10	.85	0.94	0.09	0.25	3.87
023				0.38	0.06	0.51	0.49	1.22	.27	.53	0.13	0.19	0.17	3.95
024			0.01	0.20	0.13	0.72	0.66	0.57	.07	0	0	0.01	0.61	2.98

Table X–5 METEOROLOGICAL SUMMARY: WIND SPEED & DIRECTION 1974-1975
(30 Foot Height)

Trailer	Item	Month												Annual
		Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	
Tower 200'	Wind Speed, 5-Min. Max. (MPH)	39	52	48	36	52	56	53	52	42	41	36	49	56
	& Associated Direction (Deg.)	203	239	205	209	193	178	179	228	188	229	244	209	178
020	Wind Speed, Hourly Max. (MPH)	11	11	18	18	17	24	20	16	19	17	20	18	24
021		19	13	19	17	20	28	21	20	16	18	16	21	28
022		15	20	18	17	19	17	15	17	15	17	19	15	20
023		25	38	32	24	38	43	38	28	25	22	21	33	43
024		19	25	25	20	33	37	31	25	21	21	23	31	37
020	& Associated Direction (Deg.)	129	129	288	293	118	155	153	300	115	301	295	158	155
021		340	344	347	345	168	162	164	312	296	275	268	135	162
022		105	270	285	285	110	126	131	286	107	287	283	118	270
023		200	246	198	193	189	175	170	213	178	216	273	189	175
024		177	162	197	230	155	172	183	212	111	303	277	175	172
020	Wind Speed, Hourly Avg. (MPH)	3	3	5	5	5	6	6	6	4	5	5	5	5
021		3	4	6	6	6	6	6	6	4	5	5	5	5
022		5	5	6	6	6	6	6	6	5	6	6	6	6
023		7	7	8	8	10	10	9	8	7	8	6	8	8
024		3	3	5	5	7	7	7	7	5	6	5	7	6
020	Wind Direction, Hourly Avg. (Deg.)	114	102	115	126	131	137	137	121	106	124	105	126	120
021		124	95	119	143	142	156	141	136	113	126	107	113	126
022		105	106	104	111	105	116	106	85	94	114	94	120	105
023		197	232	202	200	202	218	217	199	164	188	216	190	202
024		95	96	129	108	153	191	186	162	109	136	82	150	133

Table X–6 METEOROLOGICAL SUMMARY:
VECTOR MONTHLY AVERAGES FOR WINDS 1974-1975

Trailer	Item	Month											
		Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.
020	Wind Speed (MPH)	1.4	1.1	2.1	2.1	1.7	2.0	1.5	1.3	1.7	1.6	0.7	1.9
	Wind Direction (Degrees)	138.6	130.0	133.0	146.4	162.6	183.1	182.1	184.0	122.4	154.8	135.9	153.8
021	Wind Speed (MPH)	1.3	0.6	2.0	2.1	2.2	2.5	1.4	1.3	1.4	1.9	0.5	1.7
	Wind Direction (Degrees)	123.2	109.7	125.3	141.7	144.3	167.8	152.1	153.1	110.4	135.2	115.5	127.9
022	Wind Speed (MPH)	3.2	3.1	3.6	3.7	2.2	2.0	1.1	0.4	2.4	2.4	1.7	3.3
	Wind Direction (Degrees)	108.9	110.4	111.3	117.5	117.0	127.4	125.6	126.2	105.2	118.7	113.4	123.0
023	Wind Speed (MPH)	3.0	3.7	4.3	4.6	6.3	6.1	4.8	4.4	2.2	4.3	2.0	5.2
	Wind Direction (Degrees)	202.4	239.0	210.4	207.2	204.2	206.3	210.4	208.6	170.9	204.0	237.9	195.2
024	Wind Speed (MPH)	1.1	1.1	2.0	2.3	3.1	4.1	3.2	3.1	1.6	2.3	0.9	3.5
	Wind Direction (Degrees)	145.5	177.5	171.5	156.8	177.4	199.0	208.9	209.4	135.8	192.2	262.4	182.8

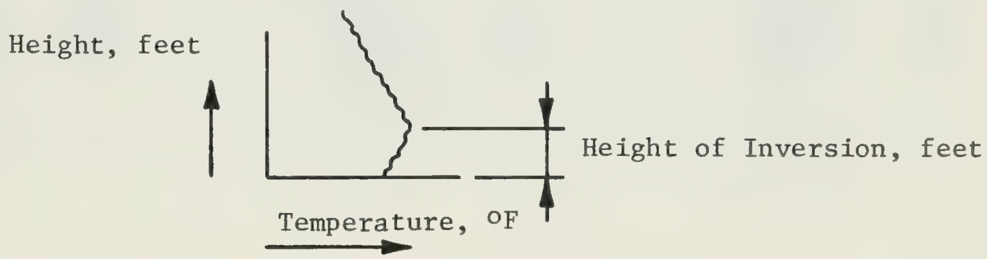
Station 021 at Rock School as an example, monthly wind roses are presented on Figure X-2 to show the frequency of the wind directions. As illustrated below, about 37% of the wind is directed down Piceance Creek and about half that amount flows up Piceance Creek (based on data from October 1974 through April 1975).

Generalized Direction	Percentage of the Time Winds Flow in a Generalized Direction
Down Piceance Creek (ESE, SE)	36.9%
Up Piceance Creek (WNW, NW)	18.9%
Subtotal	56.8%
East	14.6%
All Others	28.6%
TOTAL	100.0%

While the dominant winds in Piceance Creek valley are from the east-southeast, the dominant wind direction on the plateau, measured at the meteorological tower, is from the south-southwest, as shown in Figure X-3. Wind roses depicting both speed and direction frequency distributions at the 100-foot level on the meteorological tower on both a quarterly and annual basis are presented in Figure X-4.

Variations in the wind speed with height, as measured on the meteorological tower, are shown in Table X-7. These data indicate that speed increases directly as the logarithm of the height. Constants for these logarithmic curves for each month appear in the lower half of Table X-7. One application of the logarithmic equations has been to compute ratios of speeds at the 7-foot heights on the mechanical weather stations to those at the 30-foot heights on the air quality stations. This results in a more complete wind field representation at common elevations. Their fit to the data is excellent, as has been indicated in Summary Reports filed with the AOSS. In general winds are stronger in the spring than in the other seasons.

Inversions in the vicinity of the Tract have been measured by upper air studies (with aircraft) and with acoustic sounders. As previously noted, if the air temperature increases with height an inversion exists. And the height of the inversion can be determined by plotting temperature versus height and noting where the slope of the air temperature curve changes from negative to positive, as seen in the following sketch:



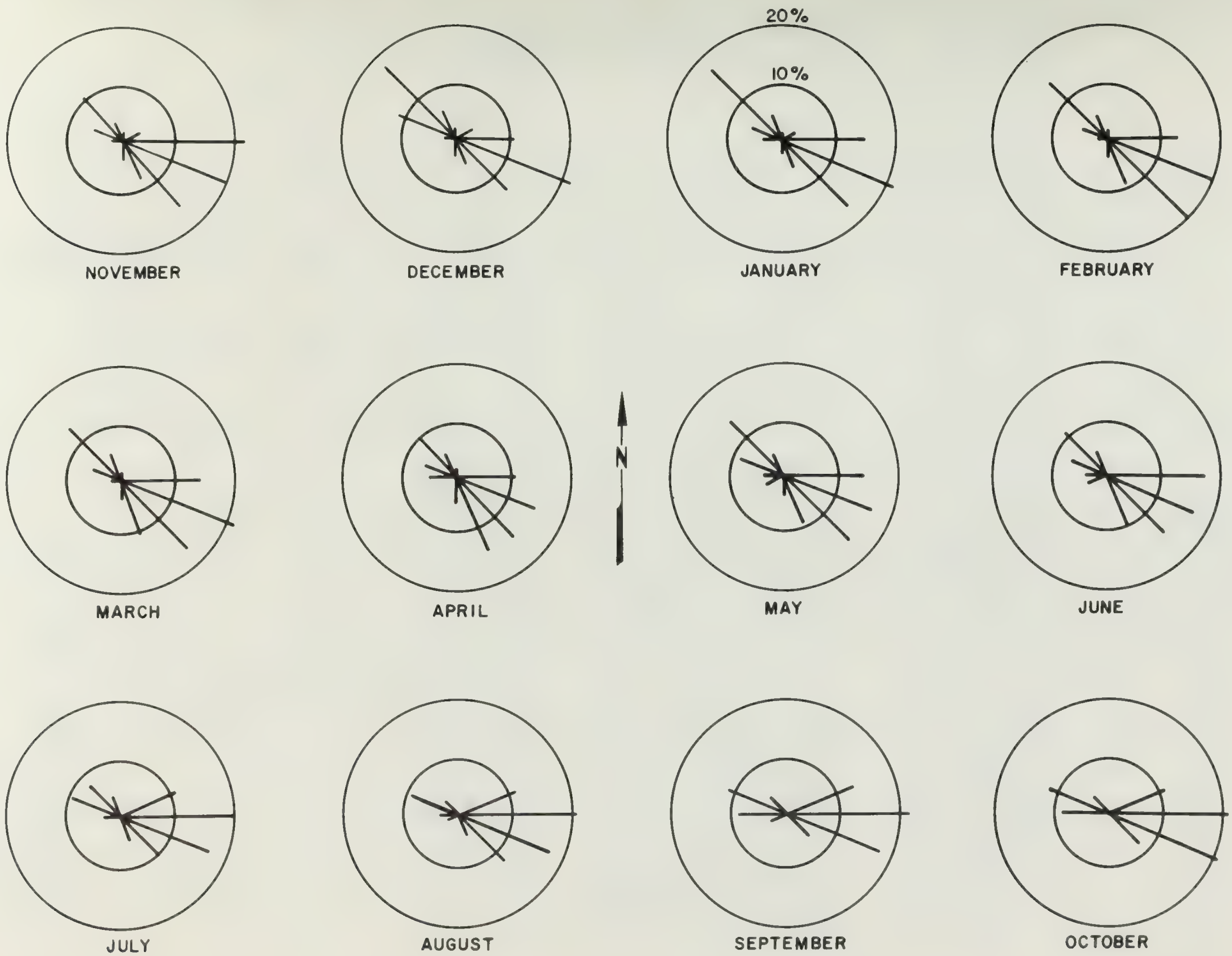


Figure X–2 STATION 021 30′ ELEVATION
MONTHLY WIND ROSES

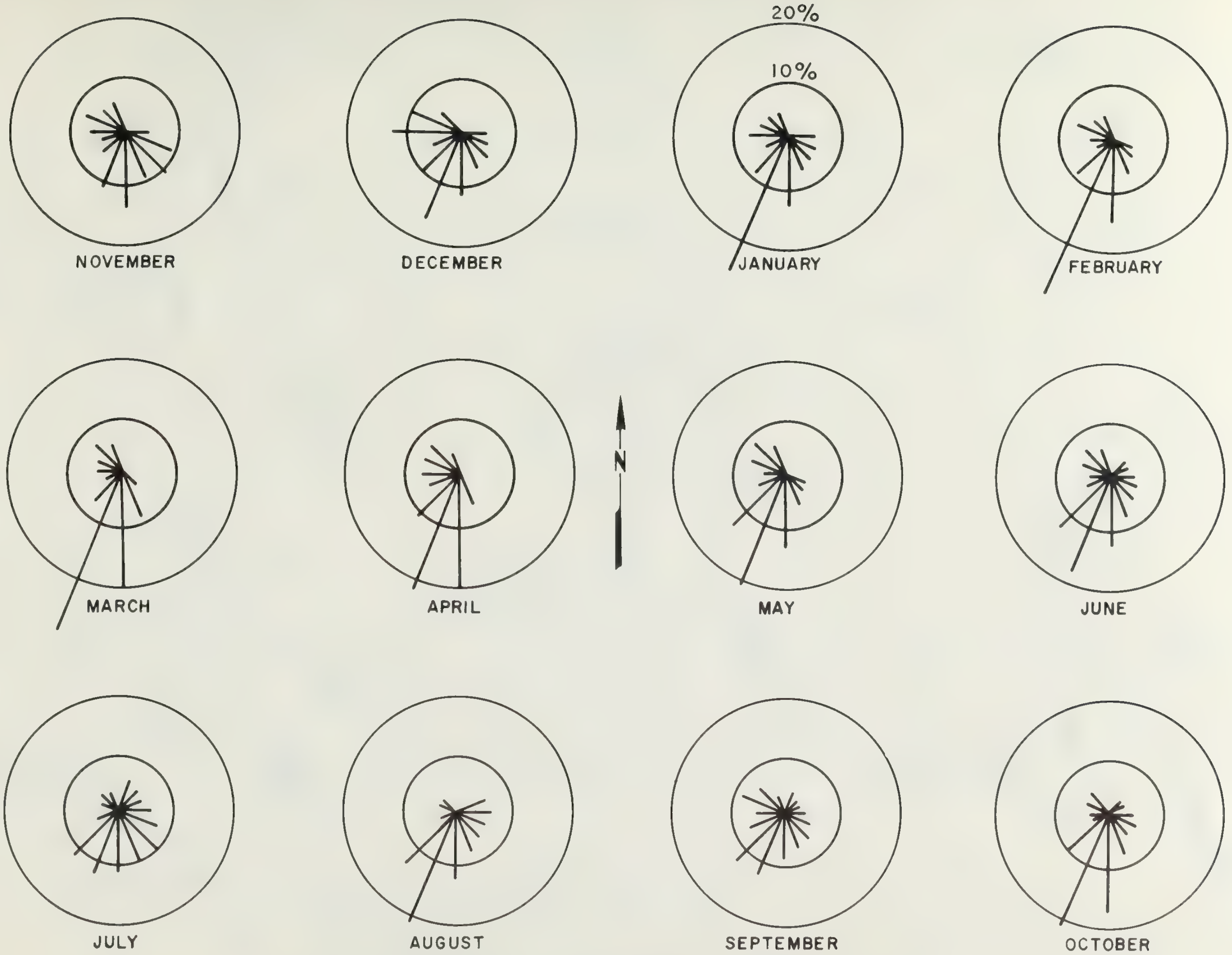


Figure X–3 STATION 023 30′ ELEVATION
MONTHLY WIND ROSES

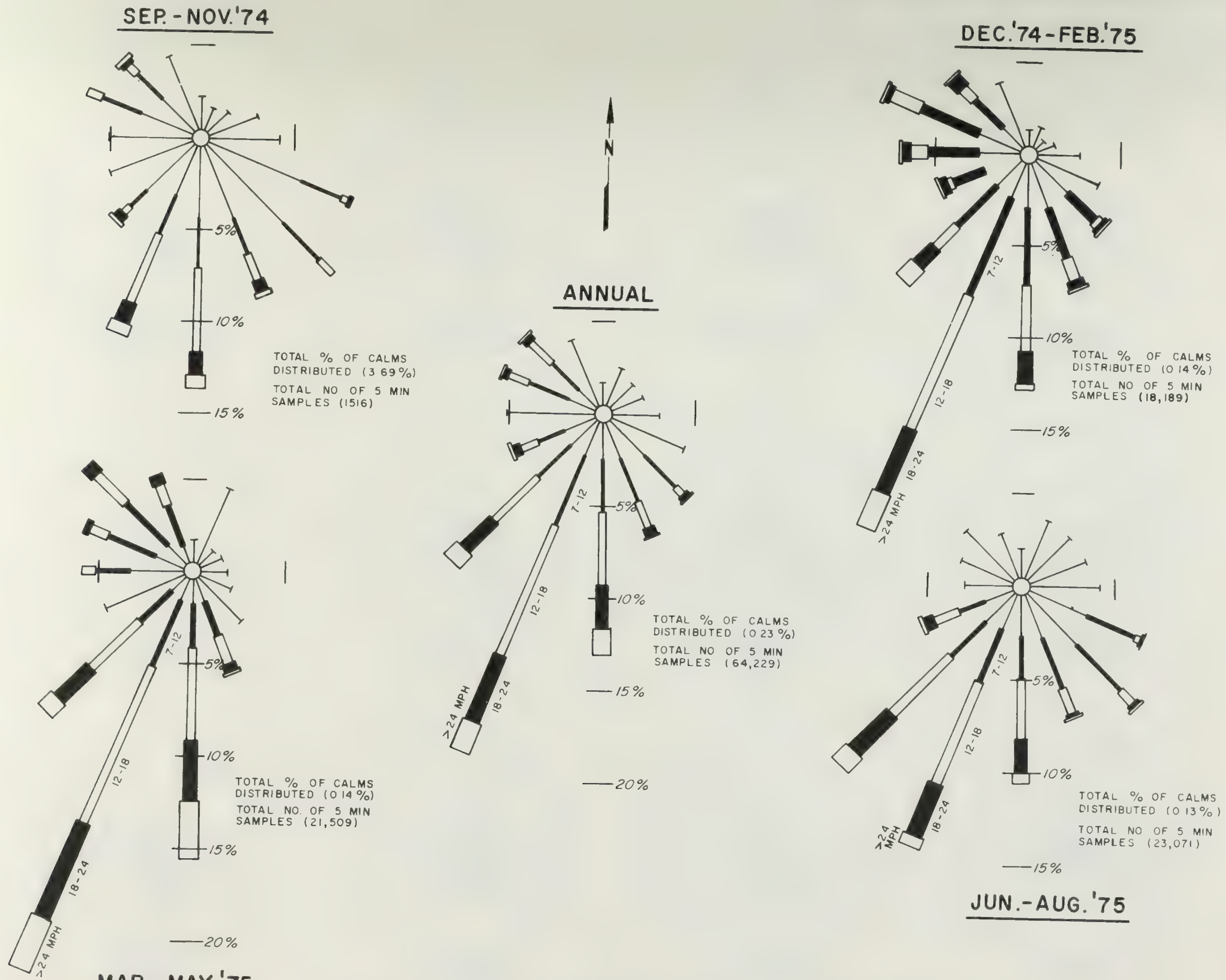


Figure X–4 METEOROLOGICAL TOWER 100′ ELEVATION
QUARTERLY AND ANNUAL WIND ROSES

Table X–7 METEOROLOGICAL SUMMARY: VERTICAL WIND PROFILE (MPH)
(Met. Tower)
1974-1975

Height on Tower (Feet) (z)	Arithmetic Mean Hourly Wind Speed for the Month												Annual
	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	
8	4	5	5	5	7	7	6	6	4	5	4	6	5
30	7	7	8	8	10	10	9	8	7	8	6	8	8
100	8	9	10	10	12	11	11	10	8	10	7	10	9
200	8	9	10	10	13	12	11	10	8	10	7	11	10
Constants for Logarithmic Fit (1)													
v^*/k (MPH)	1.26	1.39	1.57	1.57	1.95	1.85	1.70	1.57	1.26	1.57	1.09	1.57	1.53
v^* (MPH)	0.50	0.56	0.63	0.63	0.78	0.74	0.68	0.63	0.50	0.63	0.44	0.63	0.61
z_o (ft.)	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22

(1) Assumed form of equation:

$v(z) = \frac{v^*}{k} \ln (z/z_o$ where
$v(z)$ = Mean wind speed at height z above surface
v^* = Friction velocity
z_o = Roughness length
k = von Karman's constant = 0.4

This type of data was obtained by aircraft temperature soundings as part of the upper air studies. Data have been taken during the four quarters, for a period of 15 days per quarter. A summary of the inversion data to date is shown in Table X-8. This table indicates the number of days when inversions occurred over Piceance Creek valley and/or over the Tract. The number of days when they occurred over either place, and the number when they occurred over both places, are shown. Summing up the data for the four quarters, inversions were observed about 57% of the days over Piceance Creek valley, 77% of the days over Tract C-b, 92% of the days over either Piceance Creek valley or the Tract and 45% of the days over both areas. Though a higher frequency of inversions is normally expected in the canyons rather than atop the plateau, the data in Table X-8 indicate otherwise. It should be recognized that because of sampling techniques, aircraft flights cannot be made in the canyons in the dark (e.g., a 5:30 a.m. flight) and, as a result, some existing inversions in the canyons may not have been reported.

While upper air temperature soundings are the most accurate means of determining inversion heights, this method is used for only 15 days per quarter, and then only during several portions of each day. For these reasons, and because a continuous record of the onset of inversions is desirable, two acoustic sounders have been installed. One is on the Tract (near the meteorological tower) and one is in Piceance Creek valley (near the Rock School Station 021). A summary of the number of inversions and their average duration and average height is given in Table X-9. This table roughly corroborates the above 77% occurrence frequency. Average inversion height varies from about 560 feet to over 1200 feet. A frequency analysis of the duration of these inversions is shown in Table X-10. About 33% of the inversions lasted up to four hours, 21% lasted from four to seven hours, 13% lasted from 7 to 10 hours, 10% lasted from 10 to 13 hours, and only 17% lasted longer than 13 hours. These data indicate that inversions persist for one day or longer in only 4% of the cases.

Atmospheric stability can be defined by using the Pasquill-Gifford Stability Classes as defined in Table X-11. In this arbitrary system, there are six classes (Class A through Class F) with Class A being the most unstable and Class F the most stable. Stability can be determined by upper air temperature soundings, by temperature measurements at various levels on the meteorological tower, by measurements of the horizontal and vertical wind directions at various levels on the meteorological tower, and by a combination of solar radiation and wind speed data. Since the upper air temperature soundings are not a continuous source of data, the other methods of determining stability (all of which are continuous sources of data) were correlated with the upper air soundings to determine which method could be used most readily and reliably. This comparison showed that the best method of continuously determining stability classes was to use the temperature differences between the 30-foot level and the 200-foot level on the meteorological tower. This

Table X–8 SUMMARY OF INVERSIONS AT THE C-b TRACT
(Source: Temperature vs. Altitude Data)

Item	Fall '74	Winter '75	Spring '75	Summer '75	Cumulative
	(Oct.)	(Jan.)	(Apr.)	(July)	
No. of Days with Inversions					
In Canyons below Tract (=C)	4	8	5	15	32
Above Tract Surface (=T)	11	11	7	14	43
C or T	12	13	10	15	50
C and T	3	6	2	14	25
No. of Successful* Days without Inversions	0	2	4	0	6
Total No. of Successful* Days	12	15	14	15	56
Percentage of Days with Inversions					
C	33.3	53.3	35.7	100.	57.2
T	91.6	73.3	50.0	93.3	76.8
C or T	100.0	86.6	71.4	100.	89.2
C and T	25.0	40.0	14.3	93.3	44.6

* A "success" is defined here as one for which (a) at least two successful flights were obtained and for which one of the flights was either at nominally 6 am or 9 am or (b) one inversion was obtained.

Table X–9 AIR TEMPERATURE INVERSION CHARACTERISTICS AS OBTAINED FROM ACOUSTIC SOUNDER ON THE C-b TRACT NEAR METEOROLOGICAL TOWER AND AIR QUALITY MONITORING STATION NO. 023 DECEMBER 7, 1974 TO SEPTEMBER 16, 1975.

	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept
Number of inversions	16	22	24	29	27	27	-	33	11	16
Average duration (hours)	19	15	12	6	4	5	-	3	4	10
Average height (feet)	740	920	935	1015	655	685	-	1202	1155	560
Number of days of measurement	25	30	28	27	21	29	0	15	11	14
Number of days of missing data	0	1	0	4	9	2	30	16	20	2

Table X–10 FREQUENCY ANALYSIS OF AIR TEMPERATURE INVERSION DURATION AS OBTAINED FROM ACOUSTIC SOUNDER ON C-b TRACT NEAR METEOROLOGICAL TOWER AND AIR QUALITY MONITORING STATION NO. 023 DECEMBER 7, 1974 TO SEPTEMBER 16, 1975.

Inversion Duration (hrs.)	Dec	Jan	Feb	Mar	Apr	May	June[1]	July[2]	Aug[3]	Sept[4]	Total Number	Total %
0- 3.9	0	1	2	9	14	8	–	25	6	3	68	33.1
4- 6.9	2	2	2	9	9	10	–	7	1	2	44	21.4
7- 9.9	2	1	5	4	2	8	–	1	1	2	26	12.7
10-12.9	0	2	6	5	2	1	–	0	2	2	20	9.8
13-15.9	1	3	5	2	0	0	–	0	1	6	18	8.8
16-18.9	5	7	1	0	0	0	–	0	0	1	14	6.8
19-21.9	1	5	1	0	0	0	–	0	0	0	7	3.4
22-24.9	0	0	1	0	0	0	–	0	0	0	1	0.5
25-30.9	2	0	0	0	0	0	–	0	0	0	2	1.0
31-35.9	1	0	1	0	0	0	–	0	0	0	2	1.0
36- <	2	1	0	0	0	0	–	0	0	0	3	1.5
											205	100.0

[1] No measurements in June

[2] July 17 - July 31, 1975 only

[3] August 1 - August 10, 1975 and August 29 - August 31, 1975 only

[4] September 1 - September 16, 1975 only

Table X–11 DETERMINATION OF PASQUILL-GIFFORD STABILITY CLASSES FROM VARIOUS SOURCES

Pasquill-Gifford Stability Class	Slope of the Temperature-Altitude Curve dT/dz (^{o}C/100m)	Standard Deviations of Wind Direction Components	
		Horizontal $\sigma\theta$ (Deg.)	Vertical $\sigma\phi$ (Deg.)
A	< -1.9	> 23	
B	-1.9 to -1.7	18 to 23	> 15
C	-1.7 to -1.5	13 to 18	9 to 15
D	-1.5 to -0.5	8 to 13	6 to 9
E	-0.5 to 1.5	4 to 8	2 to 6
F	1.5 to 4.0	2 to 4	0 to 2
G	> 4.0	< 2	

method was shown to always be in agreement, within at least one stability class, with the stability class determined from upper air data.

Using the meteorological tower temperature difference method, the monthly average stability classes for each hour were developed. These are shown in Table X-12. The monthly average stability class frequencies are presented in Table X-13. These two tables show that in the fall and winter months the air masses are generally more stable (Classes E and F) than in the spring and summer (Classes A and B). Generally in the fall and winter, the air mass is more stable during the daylight hours than at night. During the spring and summer the air mass becomes less stable during the daylight hours, probably due to warming of the air with higher stability at night.

2. Air Quality

In general, the air quality program on the Tract has shown that the average background concentrations of the constituents monitored are fairly low. The data, however, have also shown that in this portion of the Piceance Creek basin, relatively high and persistent (one hour or longer) concentrations of most of the constituents measured can also exist. This indicates that while this area is largely undeveloped and rural in nature, the influences of man and nature can have signigicant short-term effects on the ambient air quality.

The long-term annual and monthly averages for the ambient air concentrations are shown in Table X-14, while the short term monthly one-hour maximum concentrations are shown in Table X-15. Sulfur dioxide and hydrogen sulfide are normally below the 5 parts-per-billion-by-volume detection threshold of the instrumentation (See the Summary Reports for a full explanation of the threshold limits and the significance of the reported data below the 5 parts-per-billion-by-volume detection threshold limit). These detection threshold limits are equivalent to 13 micrograms per cubic meter ($\mu g/m^3$) for SO_2 and 7 $\mu g/m^3$ for H_2S. Ambient concentrations of sulfur dioxide have also been determined on a spot-check basis using the West-Gaeke wet chemical method. This analytical method has shown that a number of ambient concentrations of SO_2 were below the 2 parts-per-billion-by-volume detection threshold limit of this method at the time when measurements were taken. The global average background concentrations for SO_2 are 1-4 $\mu g/m^3$ and for H_2S are 0.3 $\mu g/m^3$.

As can be seen from the detailed data presented in the monthly data reports and the monthly one-hour maximums summarized in Table X-15, relatively high ambient air hydrogen sulfide and sulfur dioxide concentrations have been measured frequently at all air quality station sites. These short-term peaks suggest the presence of source(s) near the Tract. Attempts to correlate the concentrations with wind direction have not indicated any patterns which would help identify the source. It is known that the Tract is virtually surrounded by natural-gas production operations and that hydrogen sulfide can occur in conjunction with natural gas. Thus H_2S could be emitted into the atmosphere. The H_2S would undergo oxidation in the atmosphere and SO_2 would be formed as a secondary pollutant.

Table X–12 AVERAGE HOURLY STABILITY CLASSES
As Obtained From Temperature Differences Between 200 ft. & 30 ft. On The Met. Tower

Month	Hour																								Average
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	
Nov.	E	E	E	E	E	E	E	F	F	F	F	F	F	F	E	E	E	E	E	E	E	E	E	E	E
Dec.	E	D	D	E	D	D	E	E	E	F	F	F	F	E	E	E	E	D	D	D	D	D	D	D	E
Jan. '75	D	D	D	D	D	D	D	D	E	E	E	E	E	E	E	E	D	D	D	D	D	D	D	D	D
Feb.	E	E	E	E	E	E	E	E	E	D	D	C	C	C	C	C	D	E	E	E	E	E	E	E	D
Mar.	D	D	D	D	D	C	C	C	A	A	A	A	A	A	A	A	A	A	C	C	D	D	D	D	C
Apr.	D	D	D	D	D	D	C	B	B	B	A	A	A	A	A	A	A	B	C	D	D	D	D	D	C
May	D	D	D	D	D	D	C	B	A	A	A	A	A	A	A	A	A	A	B	C	D	D	D	D	B
June	E	E	E	E	E	E	D	B	A	A	A	A	A	A	A	A	B	B	B	C	D	D	E	E	C
July*	—	—	—	—	—	—	—	—	—	—	—	A	A	A	A	A	A	B	—	—	—	—	—	—	A*
Aug.	F	F	F	F	F	F	F	D	B	A	A	A	A	A	A	A	A	B	D	E	F	F	F	F	D
Sept.	F	F	F	F	F	F	F	E	B	A	A	A	A	A	A	A	A	C	E	E	E	F	E	F	D
Oct.	E	E	E	E	E	E	E	D	C	A	A	A	A	A	A	A	A	C	D	D	E	E	E	E	C

*Partial Data Only

Table X–13 METEOROLOGICAL SUMMARY: STABILITY CLASS FREQUENCIES (%)
1974-1975

Source: Met. Tower
(30' to 200')

Pasquill-Gifford Stability Class	dT/dz Range for this Stability Class (°C/100m)	Month												Annual
		Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	
A	<– 1.9	2.0	17.4	12.5	6.3	45.4	48.4	57.2	42.9	75	35.8	33.0	39.3	34.6
B	–1.9 to –1.7	0.4	1.3	2.7	1.5	6.5	4.1	3.1	4.6	2.5	4.4	3.4	3.1	5.0
C	–1.7 to –1.5	0	1.5	3.8	0.7	6.5	3.9	2.8	4.4	0	2.2	2.8	4.8	2.8
D	–1.5 to –0.5	5.3	19.0	22.6	33.7	27.0	20.6	12.3	16.1	0	7.5	8.0	11.7	15.3
E	–0.5 to –1.5	62.8	40.3	31.5	41.8	14.1	17.7	12.2	17.7	0	15.1	23.5	18.7	24.6
F	>1.5	29.5	20.5	26.9	16.0	0.5	5.3	12.4	14.3	0	35.0	29.3	22.4	17.7
Total		100	100	100	100	100	100	100	100	100	100	100	100	100

Table X-14 MONTHLY AVERAGE AMBIENT AIR CONSTITUENT CONCENTRATIONS OF GASES AND PARTICULATES ($\mu g/m^3$)

1974-1975

Trailer	Item	Month												Annual
		Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	
020	NO ($\mu g/m^3$)	1.9	0.7	3.4	*0.4	*0.3	9.6	17.8	*3.2	*0.4	9.1	*3.2	3.5	4.5
023		4.4	*12.8	14.7	0.4	*1.2	0.6	0.1	0.3	0.6	1.4	0.6	0.3	3.1
020	NO_2 ($\mu g/m^3$)	2.8	6.8	4.5	*2.5	*1.2	2.7	4.1	*0.3	*1.7	4.7	*3.0	7.9	3.5
023		2.4	*4.7	7.4	0.2	*0.4	0.9	0.5	0.0	1.5	1.0	0.1	0.7	1.7
020	O_3 ($\mu g/m^3$)	58.0	69.3	93.7	105.1	88.0	77.1	71.5	69.1	74.6	50.8	41.1	32.8	69.3
023		*31.4	28.0	42.4	85.8	85.6	90.5	87.3	84.4	86.1	61.0	53.4	43.3	64.9
020	Non-Methane H.C. ($\mu g/m^3$)	73.4	97.4	*75.7	23.4	38.6	327.6(2)	38.9	50.8	25.8	27.9	58.9	75.9	76.2
023		933.0(1)	20213.6(1)	*662.8(1)	22.1	*17.1	49.1	43.3	196.5	220.2	145.6	92.2	331.8	124.2
020	CH_4 ($\mu g/m^3$)	826.1	918.8	*908.1	879.4	829.8	590.6(2)	833.6	821.2	825.9	908.8	949.3	935.6	852.3
023		825.5	1053.8(1)	*943.6(1)	*833.7	*859.8	836.3	834.3	814.7	780.7	902.7	933.4	814.1	845.5
020	CO ($\mu g/m^3$)	553.8	676.9	908.2	1228.5(2)	1498.0(2)	*853.0(2)	1815.5(2)	1092.1(2)	206.5(2)	1117.2	1154.4	3742.8	1237.2
023		3703.6(1)	2439.3(1)	1786.2(1)	391.4	504.5	485.8	699.9	437.0	468.5	820.3	721.7	*3281.1	867.8
020	SO_2 ($\mu g/m^3$)	0	1.8	0	0.1	1.1	0.1	0	1.0	1.6	0.9	0.7	1.4	0.7
021		1.3	1.7	0.8	0.8	0.6	1.2	1.1	2.1	1.3	1.9	1.7	1.8	1.4
022		2.6	0.1	0	0.2	0	0	0.5	1.7	0.4	0.6	0	0.6	0.6
023		0	6.4	3.3	0.1	0.6	0.5	0	0.0	0.6	2.0	0.9	0.2	1.2
024		0.2	1.7	1.3	5.5	0.9	1.1	0.7	0.6	0.1	0.9	0.7	2.0	1.3
020	H_2S ($\mu g/m^3$)	0	0	0	0	0.4	0	0	0.2	0	0	0.1	0.1	0.1
021		1.6	0	0.2	0.8	0.4	0.2	0.4	0.7	0.2	0.4	0.7	0.8	0.5
022		0.2	1.2	0	0.2	0.3	0.7	0	0.4	0.2	0.3	0.4	0.2	0.3
023		0	5.2	2.5	0.7	2.7	0.5	0.3	0.3	4.8	2.4	2.1	0	1.8
024		0	0.1	0	0.2	0.4	1.0	0.3	1.1	0.1	0.1	0.6	1.0	0.4
020	Particulate ($\mu g/m^3$)	*48.7(3)	4.3	3.3	3.8	6.5	11.6	12.4	10.7	14.7	18.6	12.8	11.2	13.2
021		*20.4	5.4	4.0	4.5	6.9	13.7	13.2	12.3	15.6	14.3	12.4	12.4	11.3
022		*35.3	4.2	2.9	3.2	5.3	11.9	11.2	9.5	14.6	11.5	12.6	9.7	11.0
023		*18.0	*6.8	*2.5	4.2	11.5	15.4	19.3	18.3	14.4	11.7	11.1	13.7	12.2
024		*117.0	2.9	2.3	3.8	4.9	10.2	11.4	8.7	11.3	10.6	9.8	12.4	17.1

* 50% Or Less Data

(1) Reported data are incorrect because of contaminated manifold.

(2) Reported data may be incorrect because of possible malfunctioning instrument.

(3) Very few particulate data points available for November 1974. The values reported were unduly influenced by the occurrence of a few unusually high 24-hour concentrations.

Table X–15 TRACT MAXIMUM GAS CONCENTRATIONS ($\mu g/m^3$)
1974-1975

Trailer	Item	Averaging Time (Hr.)	Month											
			Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.
020	NO	1	44.3	16.4	43.7	7.8	4.7	27.1	34.0	29.8	3.1	38.1	26.5	34.2
023	NO	1	38.5	93.9	114.2	52.6	16.7	10.1	4.2	28.7	15.3	17.0	16.5	9.0
020	NO_2	1	26.7	36.0	17.6	14.4	11.2	16.7	17.0	20.8	33.9	12.4	9.1	20.2
023	NO_2	1	21.2	47.0	68.2	9.2	4.8	10.1	8.0	3.7	13.2	59.9	9.3	7.6
020	O_3	1	108.1	117.9	130.9	146	146.2	115.3	124.5	160.4	130.9	114.0	80.8	56.2
023	O_3	1	64.6	68.5	97.7	136	145.9	116.1	139.5	152.2	129.9	127.0	135.3	58.0
020	Non-Methane H.C.	3 (6-9 A.M.)	197.6	179.7	223.8	51.4	288.6	707.7(2)	83.5	141.2	69.6	42.1	319.4	486.9
023	Non-Methane H.C.	3 (6-9 A.M.)	(1)	(1)	(1)	18.1	34.2	302.2	120.0	355.1(2)	895.6(2)	520.4	349.6	533.2
020	CH_4	3 (6-9 A.M.)	933.2	1219.5	999.2	1298.0	998.8	837.8	924.0	862.5	859.2	1009.0	1068.1	1342.9
023	CH_4	3 (6-9 A.M.)	(1)	(1)	(1)	900.1	910.2	902.4	903.9	879.1	879.4	979.5	1029.5	964.3
020	CO	1	1353.8	1853.7	1700.8	1716.6(2)	3680.4(2)	1811.5(2)	3296.9(2)	4650.9(2)	2065.3(2)	2147.1	2049.7	4227.9
023	CO	1	(1)	(1)	(1)	769.7	2421.1	740.9	1155.9	790.8	1635.9	1444.3	1763.3	4452.1
020	SO_2	1	4.6	17.4	2.6	7.6	32.8	7.2	7.6	20.8	33.9	12.4	9.1	20.2
021			32.8	25.8	53.4	23.2	21.3	21.7	34.3	67.9	18.2	16.9	11.3	20.8
022			13.0	20.8	5.9	11.7	14.1	2.6	18.2	27.4	14.5	16.3	2.4	13.0
023			0.2	97.9	50.6	5.0	12.2	8.2	7.2	3.7	13.2	59.9	9.3	7.6
024			5.2	128.5	54.3	34.3	50.8	49.1	56.4	33.0	10.6	26.5	20.6	41.7
020	H_2S	1	10.1	2.2	6.2	13.7	12.5	2.2	1.2	21.7	2.9	5.9	1.7	2.1
021			58.9	4.6	4.7	9.5	7.3	4.3	9.0	13.8	3.5	8.3	6.9	13.8
022			4.7	8.4	2.4	14.3	14.1	10.1	1.3	11.9	5.7	4.3	3.8	11.9
023			3.2	45.3	28.4	8.2	19.1	6.5	6.9	8.0	71.2	38.5	15.1	1.8
024			8.3	7.7	27.6	8.1	8.5	62.5	56.9	70.9	3.0	8.5	10.4	20.9

(1) Reported data incorrect due to manifold contamination
(2) Reported data may be incorrect because of possible malfunctioning instrument.

Ozone is considered to have a global average background level of between 40 and 80 $\mu g/m^3$. Ozone as a constituent of the urban atmosphere is a secondary pollutant, i.e., it is not emitted into the atmosphere as such, but is the result of atmospheric reaction involving other emitted pollutants - primarily hydrocarbons and nitrogen oxides in a photochemically induced reaction.

Annual average ozone levels on the Tract of about 70$\mu g/m^3$ are reported in Table X-14. These levels tend towards the upper range of the normal ozone background levels found in other rural, non-polluted areas. The one-hour maximum ozone concentration is near 160 $\mu g/m^3$, as shown in Table X-14. As can be seen, relatively high ozone values occur with some regularity on the Tract and in the Piceance Creek valley. Similarly, the occurrence of high ozone concentrations in rural areas has been documented on numerous occasions by various air monitoring networks throughout the nation.

A review of the data indicates a well-defined diurnal cycle similar to that which results from photochemical oxidant formation. It does not seem probable that such a cycle and the resulting higher ozone levels could be caused by ozone transport or transportation of ozone precursors from urban areas. It further seems improbable that stratospheric transport of ozone would produce these consistent diurnal cycles. Natural sources of ozone, possibly as a result of photochemically induced reactions involving naturally occurring hydrocarbons, may provide a more plausible explanation. However, further data gathering and analyses may fail to definitively identify the source of the observed ambient air ozone in the Tract vicinity.

The global average background carbon monoxide concentration is 100-200 $\mu g/m^3$. It can be seen from the long term annual and monthly averages in Table X-14 that the Tract carbon monoxide levels are considerably above this. The data imply that the regional atmospheric concentrations are also well above the background concentration. The short-term monthly one-hour maximums in Table X-15 indicate a nearby source and are undoubtedly influenced by automobile traffic on the Tract and in the Piceance Creek valley.

The monthly averages for methane shown in Table X-14 are in agreement with the global average background range of 814-977 $\mu g/m^3$. The non-methane hydrocarbon (NMHC) 6:00-9:00 a.m. maxima in Table X-15 and annual and monthly average in Table X-14 show much greater variation than the methane concentrations. The difference between the Piceance Creek valley and Tract sites are often substantial. Considerable caution is urged in the interpretation of these data. EPA tests have shown that the precision and reliability of NMHC measurement determined by subtractive gas chromatography is poor. With this in mind, the data for Station 023 located on the Tract seems to indicate increasingly higher NMHC concentrations from June through October. This trend may, in part,

be caused by the volatilization of naturally occurring organic compounds as a result of the seasonally warmer temperatures and increased vegetation growth at that time of the year. Further data collection and analyses may substantiate this interpretation. The automobile traffic in the area is yet another source of hydrocarbons and undoubtedly affects the ambient air concentration.

The ambient air concentrations of oxides of nitrogen indicate that frequently instances occur above the global average background levels of 0.25-2.15 $\mu g/m^3$ for nitric oxide and 1.9-2.6 $\mu g/m^3$ for nitrogen dioxide. The data do not indicate any obvious trends or patterns, but these gases are known to be emitted by automobiles as well as other combustion processes.

The monthly average ambient concentrations of particulates (Table X-14) seem to exhibit a seasonal trend. The lowest concentration occur during the winter months, when the snow cover, lower wind speeds and decreased level of activity in the area tend to reduce the amount of fugitive dust. Relatively high particulate concentrations have been measured, as noted in Table X-16. Particulate concentrations are affected by fugitive dust from open fields, construction activity, traffic over dirt roads, agricultural activities in the valley and possibly from naturally occurring organic aerosols.

Special cellulose filters having low background levels of trace element content have been utilized every sixth day at Station 023. These filters were combined into a composite sample once each quarter and analyzed to determine average ambient air concentrations of trace elements and radioactivity levels. The composite trace element concentrations are shown in Table X-17. Spot check samples using a single filter were used to detect any gross short-term variations from the average. These data are shown in Table X-18. The volatile trace metals selenium, mercury and arsenic (analyzed as arsine, AsH_3) were collected and analyzed once each quarter by specialized techniques. The results are reported in Table X-19. The ambient air trace-element levels reported to date have been quite low. Further quantitative analysis would have been performed if high levels of toxic elements had been detected, or if beta radiation exceeded one picocurie per cubic meter, or if large increases in gross radioactivity had occurred. Radioactivity levels shown in Table X-20 are well below the one picocurie per cubic meter level and can be considered as normal background levels.

Particulate mass distributions by aerodynamic size range have been determined once each quarter using an Andersen high volume cascade impactor sampler. These data are reported in Table X-21. The data may provide an additional assessment of development-related and operation-related impacts.

Table X–16 TRACT MAXIMUM PARTICULATE CONCENTRATIONS ($\mu g/m^3$)
MIDNIGHT - MIDNIGHT
1974-1975

Trailer	Item	Month											
		Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.
020	Value ($\mu g/m^3$)	133.0	11.0	17.0	11.0	39.0	39.0	70.0	48.0	47.0	49.0	44.0	62.0
	Max. 1-hr. avg. Wind Speed (MPH)	5	8	8	5	14	24	20	12	6	8	8	15
	Wind Speed 24-hr. avg. (MPH)	2	3	5	4	7	15	10	6	4	5	4	8
021	Value ($\mu g/m^3$)	71.0	18.0	7.0	10.0	32.0	125.0	97.0	75.0	28.0	37.0	8.0	87.0
	Max. 1-hr. avg. Wind Speed (MPH)	10	9	6	8	20	28	21	14	9	8	14	21
	Wind Speed 24-hr. avg. (MPH)	4	4	3	4	9	14	12	9	4	5	7	8
022	Value ($\mu g/m^3$)	154.0	116.0	10.0	12.0	44.0	82.0	80.0	55.0	69.0	27.0	60.0	70.0
	Max. 1-hr. avg. Wind Speed (MPH)	9	9	12	12	9	16	15	8	11	14	10	12
	Wind Speed 24-hr. avg. (MPH)	5	5	5	7	5	13	9	5	7	8	7	8
023	Value ($\mu g/m^3$)	26.0	22.0	6.0	11.0	171.0	112.0	107.0	65.0	42.0	31.0	33.0	81.0
	Max. 1-hr. avg. Wind Speed (MPH)	15	18	16	5	38	41	34	23	18	20.	18	30
	Wind Speed 24-hr. avg. (MPH)	7	10	8	4	16	27	17	11	9	11	7	16
024	Value ($\mu g/m^3$)	178.0	8.0	16.0	9.0	27.0	80.0	86.0	52.0	27.0	30.0	26.0	80.0
	Max. 1-hr. avg. Wind Speed (MPH)	8	7	5	8	33	37	30	18	21	14	7	25
	Wind Speed 24-hr. avg. (MPH)	4	2	3	4	13	22	14	9	6	5	5	15

Table X-17 AMBIENT CONCENTRATIONS OF TRACE ELEMENTS ON TRACT C-b

Composite Samples

Concentrations in $\mu g/m^3$

	Composite of Winter, 1974 Samples	Composite of Spring, 1975 Samples	Composite of Summer, 1975 Samples	Composite of Fall, 1975 Samples		Composite of Winter, 1974 Samples	Composite of Spring, 1975 Samples	Composite of Summer, 1975 Samples	Composite of Fall, 1975 Samples		Composite of Winter, 1974 Samples	Composite of Spring, 1975 Samples	Composite of Summer, 1975 Samples	Composite of Fall, 1975 Samples		Composite of Winter, 1974 Samples	Composite of Spring, 1975 Samples	Composite of Summer, 1975 Samples	Composite of Fall, 1975 Samples
Uranium	7×10^{-5}	2×10^{-3}			Terbium					Ruthenium					Vanadium	4×10^{-4}	2×10^{-4}		
Thorium	6×10^{-5}				Gadolinium					Mclybdenum	2×10^{-4}				Titanium	4×10^{-3}	6×10^{-3}		
Bismuth	2×10^{-5}	1×10^{-4}			Europium					Niobium	6×10^{-5}				Scandium				
Lead	3×10^{-3}	2×10^{-3}			Samarium					Zirconium	3×10^{-4}				Calcium	.3	.44		
Thallium					Neodymium	4×10^{-4}	1×10^{-4}			Yttrium	1×10^{-4}	1×10^{-4}			Potassium	.1	.26		
Mercury	2×10^{-5}	2.05×10^{-8}			Praseodymium	3×10^{-5}	2×10^{-5}			Strontium	3×10^{-3}	2×10^{-4}			Chlorine	1×10^{-3}			
Gold					Cerium	1×10^{-4}	1×10^{-4}			Rubidium	2×10^{-3}	9×10^{-4}			Sulphur	7×10^{-3}	6×10^{-2}		
Platinum					Lanthanum	9×10^{-5}	5×10^{-5}			Bromine		1×10^{-4}			Phosphorus	3×10^{-3}	4.2×10^{-2}		
Iridium					Barium	1×10^{-3}	1×10^{-3}			Selenium	8×10^{-7}	6×10^{-5}			Silicon		.42		
Osmium					Cesium	7×10^{-5}				Arsenic	1×10^{-4}	1×10^{-3}			Aluminum	.1	2×10^{-2}		
Rhenium		Internal Standard			Iodine					Germanium	3×10^{-5}				Magnesium	.2	3.6		
Tungsten	4×10^{-5}				Tellurium					Gallium	1×10^{-4}	1×10^{-5}			Sodium	5×10^{-2}	4.2		
Tantalum					Antimony	5×10^{-5}	8×10^{-5}			Zinc	1×10^{-2}	9×10^{-3}			Fluorine	1×10^{-2}			
Hafnium					Tin	6×10^{-4}	2×10^{-4}			Copper	9×10^{-3}	6×10^{-2}			Oxygen		NR		
Lutecium					Indium		Internal Standard			Nickel	4×10^{-4}	3×10^{-4}			Nitrogen		NR		
Ytterbium					Cadmium					Cobalt	3×10^{-4}				Carbon		NR		
Thullium					Silver	6×10^{-5}	2×10^{-5}			Iron	3×10^{-2}	2.6			Boron	2×10^{-2}			
Erbium					Palladium					Manganese	3×10^{-3}	7×10^{-2}			Beryllium	2×10^{-7}			
Holmium					Rhodium					Chromium	7×10^{-4}				Lithium	1×10^{-4}			
Dysprosium					Radium	2.7×10^{-15}	2.7×10^{-15}								Radium				

Notes: NR – Not reported

When no number appears, concentration is less than 1×10^{-5} $\mu g/m^3$

Table X–18 TRACE ELEMENT ANALYSIS OF SINGLE FILTER SAMPLES ON TRACT C-b

Concentrations in $\mu g/m^3$

	Single Filter Sample 12/4/74	Single Filter 1/28/75	Single Filter	Single Filter		Single Filter Sample 12/4/74	Single Filter 1/28/75	Single Filter	Single Filter		Single Filter Sample 12/4/74	Single Filter 1/28/75	Single Filter	Single Filter		Single Filter Sample 12/4/74	Single Filter 1/28/75	Single Filter	Single Filter
Uranium	5×10^{-5}				Terbium					Ruthenium					Vanadium	2×10^{-3}	5×10^{-4}		
Thorium	3×10^{-5}				Gadolinium					Mclybdenum	5×10^{-4}	1×10^{-3}			Titanium	9×10^{-3}	1.4×10^{-2}		
Bismuth	3×10^{-5}	1×10^{-3}			Europium					Niobium	7×10^{-5}	2×10^{-5}			Scandium				
Lead	1×10^{-2}				Samarium					Zirconium	1×10^{-3}	6×10^{-5}			Calcium	1.1	.5		
Thallium					Neodymium	9×10^{-5}				Yttrium	2×10^{-4}	2×10^{-4}			Potassium	0.7	.42		
Mercury	1×10^{-5}	2.1×10^{-8}			Praseodymium	7×10^{-5}				Strontium	6×10^{-3}	5×10^{-3}			Chlorine	3×10^{-3}			
Gold					Cerium	5×10^{-4}	1×10^{-4}			Rubidium	4×10^{-3}	2×10^{-4}			Sulphur	7×10^{-2}	1.8×10^{-2}		
Platinum					Lanthanum	2×10^{-4}	1×10^{-4}			Bromine	7×10^{-5}	7×10^{-4}			Phosphorus	5×10^{-3}	2.1		
Iridium					Barium	2×10^{-3}	2×10^{-3}			Selenium	8×10^{-5}	1×10^{-4}			Silicon		1.8		
Osmium					Cesium	1×10^{-4}				Arsenic	7×10^{-4}	2×10^{-3}			Aluminum	.2	.12		
Rhenium	Internal Standard				Iodine		8×10^{-4}			Germanium		2×10^{-5}			Magnesium	0.5	3.9		
Tungsten	3×10^{-5}				Tellurium	4×10^{-5}				Gallium	5×10^{-4}	2×10^{-5}			Sodium	6×10^{-2}			
Tantalum					Antimony	2×10^{-4}	5×10^{-5}			Zinc	2×10^{-2}	3×10^{-3}			Fluorine	4×10^{-3}	.25		
Hafnium					Tin	2×10^{-3}	2×10^{-4}			Copper	2×10^{-2}	2×10^{-3}			Oxygen		NR		
Lutecium					Indium		Internal Standard			Nickel	3×10^{-4}	4×10^{-4}			Nitrogen		NR		
Ytterbium					Cadmium	8×10^{-7}	2×10^{-4}			Cobalt	4×10^{-4}				Carbon		NR		
Thullium					Silver	1×10^{-4}				Iron	7×10^{-2}	1.6			Boron	8×10^{-3}	9×10^{-3}		
Erbium					Palladium					Manganese	1×10^{-2}	5×10^{-2}			Beryllium	2×10^{-6}			
Holmium					Rhodium					Chromium	1×10^{-3}				Lithium	3×10^{-4}			
Dysprosium					Radium										Radium				

Notes: NR – Not Reported
When no numbers appear, concentration is less than 1×10^{-5} $\mu g/m^3$

Table X–19 VOLATILE TRACE METAL CONCENTRATIONS - $\mu g/m^3$ ON TRACT C-b

Date of Sample Collection	Selenium(1)	Mercury(2)	Arsine(3)
November 22, 1974	0.30	0.0350	8.00
January 27, 1975	0.00	0.0000	0.00
April 25, 1975	0.38	0.0055	9.74
July 25, 1975	0.16	0.0027	7.83

(1) Detection limit threshold 0.05 $\mu g/m^3$

(2) Detection limit threshold 0.001 $\mu g/m^3$

(3) Detection limit threshold 0.5 $\mu g/m^3$

Table X–20 GROSS RADIOACTIVITY LEVELS ON TRACT C-b

PICOCURIES/m^3

Date of Sample Collection	Gross Alpha ± Precision (1)	Gross Beta ± Precision (1)
Composite of Samples, Nov. - Dec., 1974	$6.5 \times 10^{-4} \pm 2.7 \times 10^{-4}$ (3)	$11.4 \times 10^{-2} \pm 0.4 \times 10^{-2}$ (2)
Single Day Sample 12/4/74	$13.8 \times 10^{-4} \pm 8.2 \times 10^{-4}$ (3)	$13.2 \times 10^{-2} \pm 0.8 \times 10^{-2}$ (2)
Composite of Samples, Jan. - Mar., 1975	$6.3 \times 10^{-4} \pm 4.1 \times 10^{-4}$ (4)	$7.1 \times 10^{-2} \pm 0.1 \times 10^{-2}$ (2)
Single Day Sample 1/28/75	$3.4 \times 10^{-4} \pm 1.3 \times 10^{-4}$ (4)	$19.6 \times 10^{-2} \pm 4.2 \times 10^{-2}$ (2)

(1) Variability of radioactivity disintegration process (counting error) at the 95% confidence level.

(2) Blank Gross Beta 0.004 + 0.004 pc./cm^2 (420 cm^2/filter).

(3) Blank Gross Alpha 0.0004 + 0.0004 pc./cm^2 (420 cm^2/filter).

(4) Blank Gross Alpha 0.0007 + 0.0006 pc./cm^2 (420 cm^2/filter).

Table X–21 SIZE DISTRIBUTION OF AIRBORNE PARTICULATE MATTER IN THE RESPIRABLE RANGES

Concentrations in g/m^3

Size Range in Microns* / Date of Sample	7.0 - Above	3.3 - 7.0	2.0 - 3.3	1.1 - 2.0	0.01 - 1.1
January 27-28, 1975	1.77	1.89	6.62	2.13	5.44(1)
April 24-25, 1975	22.06	15.25	6.81	5.31	3.44
July 24-25, 1975	5.02	3.43	2.64	1.85	1.58
October 4-5, 1975	3.66	3.05	2.01	0.91	4.08(1)

* Aerodynamic diameter of the particulate matter.

(1) Two soot particles of much larger diameter were observed on filter, therefore, this is not an accurate ambient air concentration.

XI. BIOTIC COMMUNITIES

A. Introduction

The data and interpretations in this section are based upon the results obtained in the first year of the two-year baseline program being conducted on Tract C-b. The methodologies and scope of the baseline program are outlined for each of the subjects addressed. A detailed description of the program also has been included in the Quarterly Data Reports and Summary Reports filed with the AOSS.

This section will include discussions of animal populations and their dynamics, plant communities and community dynamics, and the methodologies, results and interpretations of the baseline program.

B. Animal Populations and Dynamics

1. Mammals

a. Predators

The major mammalian predators in the Tract area have been identified by direct observation, live trappings, track counts, vocalizations and indirect sign such as droppings, denning sites and remains of kills. These predator species are listed in Table XI-1. The wildlife study areas are shown in Figure XI-1.

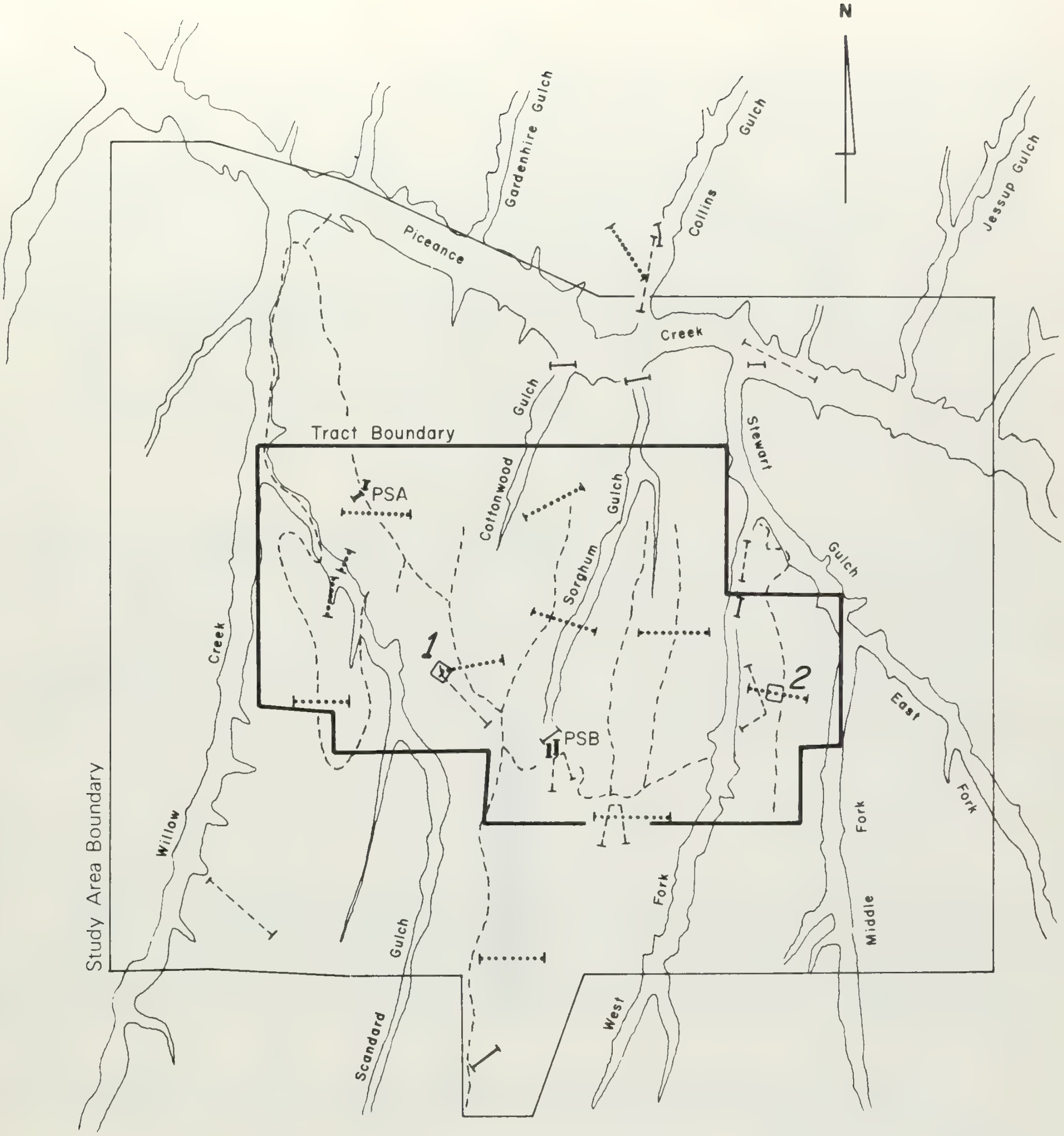
A quantitative method of estimating coyote abundance was utilized to compare the local coyote population with estimates obtained at established sampling stations in Colorado and throughout 17 western states. The method was developed by the U. S. Fish and Wildlife Service. This standardized scent station technique consists of 50 stations located at 0.3 mile intervals along a transect that covers a distance of 15 miles. Each station is a 3-foot circle of sifted earth with a capsule containing an attractant placed in the center. All stations were observed for five successive days. The relative abundance of coyotes was calculated as a visit frequency.

The coyote is common in the Tract area and has been identified in almost all habitat types. Results obtained using the standard scent station technique indicated that the coyote density near the Tract was relatively high compared to other areas of Colorado. An abundance index of 188 was obtained for the Tract in September 1974. Of 20 indices obtained for Colorado, also taken during September 1974 and using identical methods, the mean index was 98, with a range of 18 to 229. The main food supply of the coyote in this area appears to be voles, cottontails, jackrabbits, and winter-killed deer.

Track counts were also conducted to further evaluate the distribution

Table XI–1 PREDATOR SPECIES IDENTIFIED IN AND AROUND TRACT C-b

Scientific Name	Common Name
Canis latrans	Coyote
Lynx rufus	Bobcat
Mustela erminea	Ermine
Mustela frenata	Long-tailed weasel
Taxidea taxus	American badger
Urocyon cinereoargenteus	Gray fox



KEY:

PSA = Parasite sample - A
PSB = Parasite sample - B
= Roads
= Ornithological study transect
= Satellite animal trapping transect
= Small mammal parasite sampling site.
= Deer pellet and browse transect.
= Small mammal trapping grid; reptile and arthropod pit-cans.

0 1 2 3 miles

Figure XI–1 TERRESTRIAL WILDLIFE STUDY AREAS

and relative abundance of the major predators and medium-sized mammals. These track studies were conducted bi-monthly, using one or more transects of 20 quadrats located in four different habitat types: pinyon-juniper woodland, chained pinyon-juniper rangeland, valley sagebrush, and agricultural meadow. Quadrats were four square meters each, and were located at 25 meter intervals. No attractant was used with this track count method, but abundance of animals was again calculated as a visit frequency.

The bobcat is most common in the rimrock areas on the Tract, although signs of bobcat activity are occasionally seen in other habitats. Prey species which are most important to bobcats include cottontail, jackrabbits, woodrats, and various birds. The bobcat, unlike the coyote, is a more specialized predator and typically does not feed on carrion. However, carrion feeding on fresh deer carcasses by bobcats was observed on two occasions during winter.

Two species of weasels have been identified on the Tract; the long-tailed weasel and the ermine. Neither is abundant, however, and only two sightings have been made. Both species commonly feed on voles and other small mammals, and occasionally on birds.

Badgers are uncommon on the Tract, but signs of past diggings into ground squirrel burrows can be seen in many areas. Recent diggings were observed in the lower section of Sorghum Gulch in the burrows of Richardson's ground squirrels.

Gray fox have not been observed on the Tract, and they are rarely seen in the area.

Raccoons are common along Piceance Creek and sometimes tracks are observed on adjacent ridges. According to local residents, raccoons are more common now than in the past. This is a semi-aquatic species that commonly feeds on aquatic organisms, although it regularly moves far from water and will feed on a variety of terrestrial plants and animals.

Striped skunks are uncommon on the Tract, but they have been observed near the agricultural meadows and riparian areas and in the pinyon-juniper woodlands.

b. Big Game

The mule deer distribution, abundance and habitat use in and around the Tract have been monitored by several techniques including road counts, aerial counts, track counts, winter mortality counts, and shrub utilization studies. Tract C-b is utilized by mule deer mainly as winter range. The local movement patterns of deer were studied during this period (October to May).

Road counts were conducted during late evenings and occasionally during mornings (Figure XI-2). Counts were made of deer observed within

NOTE:

Counts were conducted during late evenings
Black bars represent deer observed *within* the 1-mile study area boundary that surrounds tract C-b.
Clear bars " " " *outside* " " " " " " " " "
Significant landmarks between Little Hills and Rio Blanco correspond to the mile intervals shown.
Arrows indicate the observational limits. Shorter road counts are required in the fall because deer movements into the meadows begin at dusk. In the spring, deer are active throughout the late afternoon, and road counts can begin earlier.

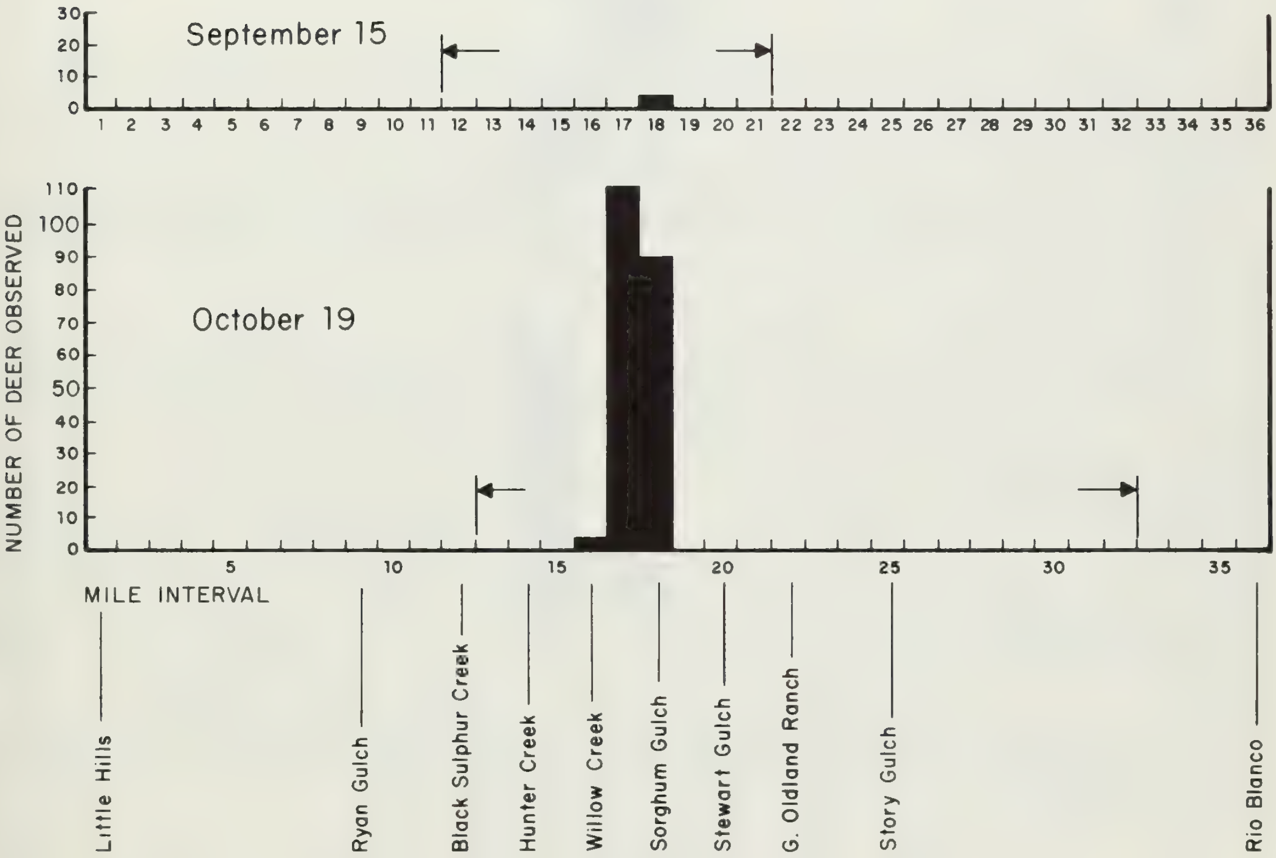


Figure XI–2 DEER ROAD COUNTS NEAR TRACT C-b (1974-1975)

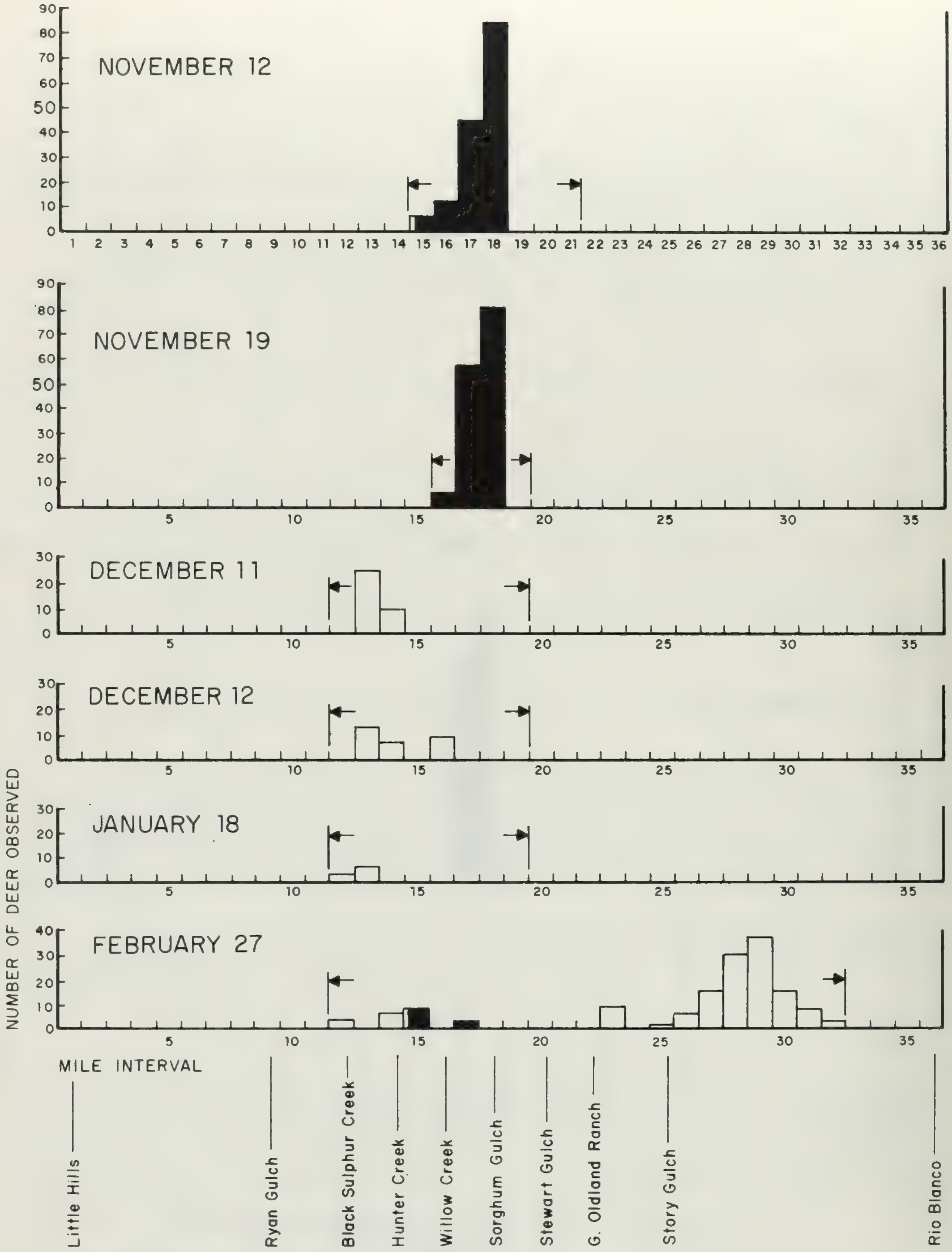


Figure XI - 2 (Continued)

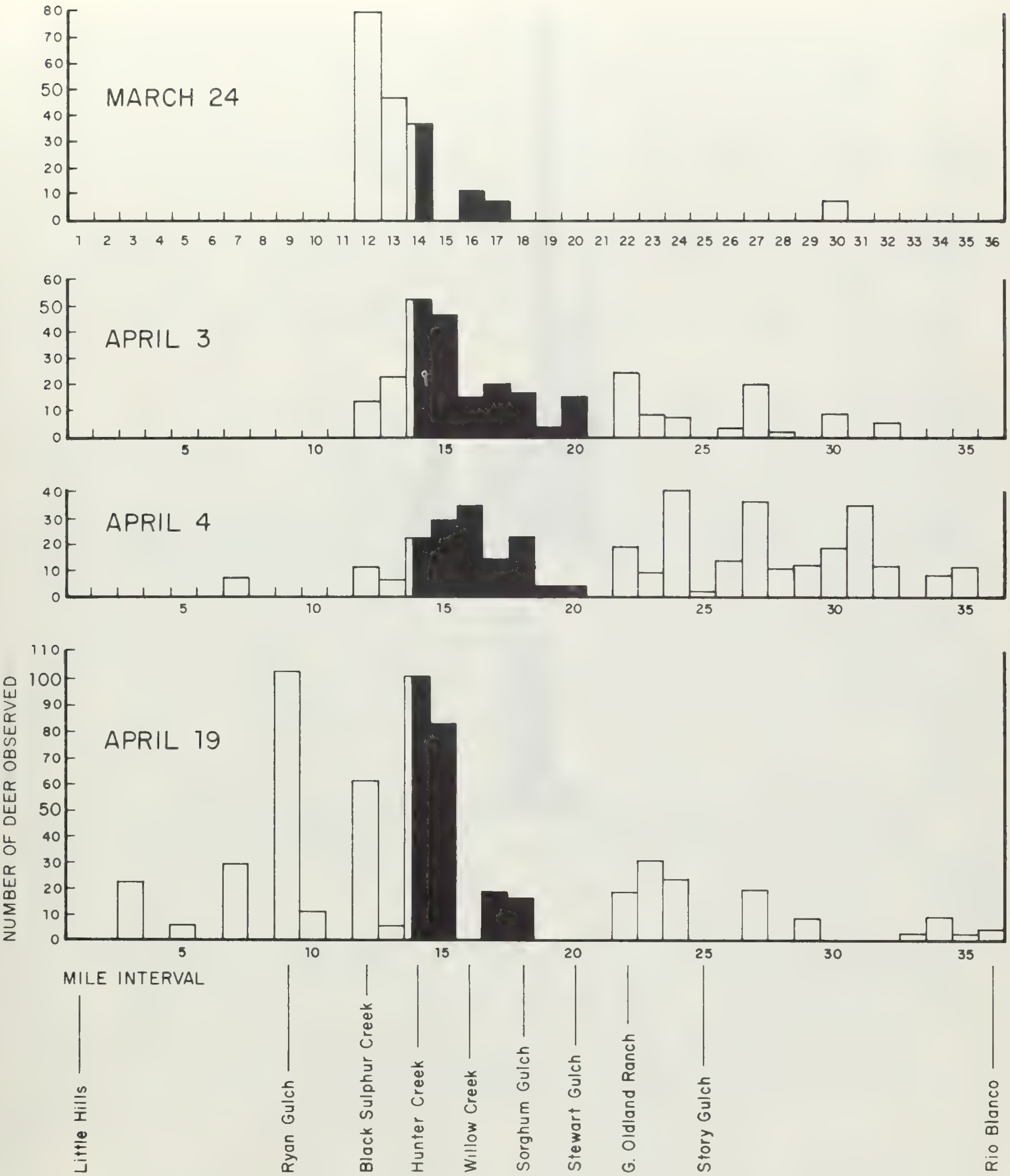


Figure XI - 2 (Continued)

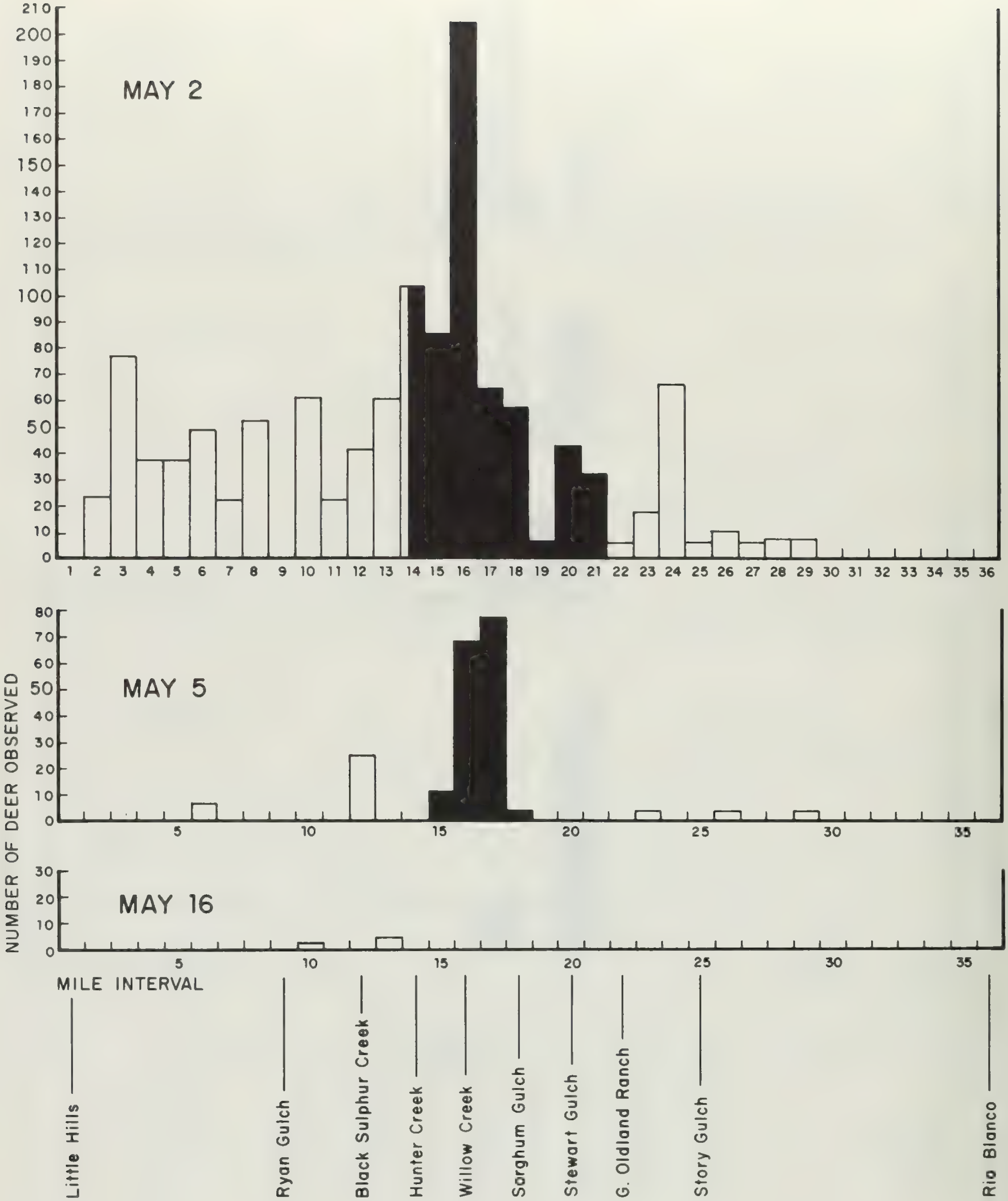


Figure XI - 2 (Continued)

one-mile intervals along the Piceance Creek road. Observations of all deer in meadows or along the adjacent slopes and alluvial fans were recorded. The road distances along which counts were conducted during the fall varied in length from 4 to 20 miles, depending on the daily feeding activities of the deer. Spring road counts were conducted between Little Hills Game Experiment Station, approximately 13 miles west of the Tract, and the Rio Blanco store, for a total distance of 36 miles.

Aerial counts were conducted over the Tract during winter following fresh snowfalls. Eight transects were flown perpendicular to drainages of Piceance Creek at about 500 feet above ground level. The abundance of deer tracks were ranked as low, medium or high. It was not feasible to divide this ranking system more finely or to count the numbers of deer actually observed.

Track count studies conducted on the ground (described in the predators section above) were useful in evaluating differential habitat usage by deer and in defining the times of fall and spring deer migrations. The routes of migratory movements taken by deer during the fall of 1975 were evaluated, using a modification of this track count method. Five transects were established on six of the major north-south ridges in the Tract area. All transects were positioned within homogeneous stands of pinyon-juniper woodland. Each transect consisted of 10 circular quadrats (1 square meter each) placed at 10 meter intervals. Transects were oriented perpendicular to the ridges and were placed approximately 400 meters apart. The occurrence of deer tracks within these quadrats was checked about every three days during a two-week period to establish when the migration began, then daily during the animals' approximately one-week migrational movement into the Tract area.

Deer mortality surveys were conducted during the winter months. Large quadrats were located in five of the major habitat types on the Tract. When deer left the Tract in the spring, a survey was conducted to count all carcasses in these quadrats. An attempt has been made to identify the age of each animal and the cause of death.

Deer pellet group counts were conducted along sixteen established transects in and around the Tract. These transects are shown in Figure XI-1. Each transect consisted of 50 circular plots, each 0.01 acres in size, spaced at 15-meter intervals. All existing pellet groups were removed from each plot prior to the survey, and in early spring, after the deer left the Tract, all new pellet groups were counted. From the pellet group survey, distribution patterns of deer and their use of the Tract has been evaluated.

A shrub utilization study has been designed to evaluate the extent to which deer utilize shrub species on the Tract. Two methods are being used for this evaluation. In the first method, browse species present in each pellet group plot are rated with respect to relative cover and degree of browsing. These cover and browse values were then used to compute percent availability and percent utilization of each browse species by

major vegetation type. Values were then combined for the Tract study area, and are shown in Table XI-2. In the second method, direct measurement of shrub material consumed by the deer was used to evaluate shrub utilization. With this method browse species present in every tenth pellet group plot (150 meter intervals) were selected for tagging in the fall of 1974. Tags were placed where the current year's growth had begun on four randomly selected shoots for each browse species. In the spring of 1975, after the deer had left their winter range, measurement of the current year's growth remaining after winter browsing was used to calculate a percent utilization for each shrub species. Species dry weights of clipped shoots will be used to estimate the biomass taken by wintering deer during 1974-1975. Table XI-3 shows the measurements for current year's growth on the tagged shrubs along with the percentage of each shoot utilized over the winter.

The above-mentioned surveys showed that relatively few deer were present on the Tract during August and September, 1974. In October, however, there was a significant influx of deer onto the Tract. Track counts conducted during October showed high deer usage of the pinyon-juniper woodland, and lower agricultural meadows (Figure XI-3). Significant deer activity was also observed in upper sagebrush valleys and the mixed mountain-shrub habitat types. During October and November, large concentrations of deer were observed feeding in off-tract agricultural meadows; the deer bedded during the day primarily in the pinyon-juniper ridges near the north boundary of the Tract. The areas of meadow concentrations are shown in Figure XI-4, which also shows the limits of summer and winter deer range near the Tract. In December and January, the deer had largely abandoned the lower meadows and valleys and were more commonly found widely dispersed throughout the pinyon-juniper woodland and chained areas.

In February 1975, there was a marked seasonal change in the distributional pattern of deer. South-facing slopes along Piceance Creek were utilized heavily for the first time since the study began. This shift in habitat usage by the deer was undoubtedly related to snow conditions. Snow was not deep during late February, but many freeze-thaw cycles caused drifts to become crusted, particularly on north-facing slopes. Although forage on the south-facing slopes is inferior to the typical understory within the better forage habitats (pinyon-juniper woodland, chained pinyon-juniper, upland sagebrush and hay meadows), crusted snow in these better habitats hindered movements over wide areas. It appears, therefore, that south-facing slopes may be important to winter survival during the more critical winter periods.

In late March, April and early May, 1975, the new spring growth in the agricultural meadows along Piceance Creek was heavily utilized by deer. In early May the deer began to move out of the meadows to the high country, and were, for the most part, gone from the Tract area by mid-May. Road and aerial counts indicated that numbers of deer were substantial in the Tract area from fall through spring, and that many habitat types were used by the deer during this period (Figures XI-5 through XI-8).

Table XI–2 WINTER DEER BROWSE EVALUATION AND UTILIZATION

Browse Species	Tract C-b Study Area % Available	Tract C-b Study Area % of Diet	Pinyon-Juniper % Available	Pinyon-Juniper % of Diet	Chained Pinyon-Juniper % Available	Chained Pinyon-Juniper % of Diet	Upland Sagebrush % Available	Upland Sagebrush % of Diet	Bottomland Sagebrush % Available	Bottomland Sagebrush % of Diet
Mountain Mahogany	5.7	9.8	9.9	13.7	5.1	10.7	.6	.9		
Antelope Bitterbrush	7.2	11.9	11.5	20.3	9.8	21.3	.4	.5		
Big Sagebrush	50.6	45.3	36.2	30.4	54.0	48.7	68.1	77.0	80.3	23.9
Serviceberry	6.7	10.7	11.0	14.7	2.4	2.3	.8	.4		
Snowberry	10.0	3.0	12.6	5.1	17.0	5.4	3.3	.3	2.4	.6
Gambel's Oak	1.9	2.5	2.8	3.0	.2	.4	.6	.9		
Rabbitbrush	14.4	15.1	11.6	10.6	11.5	11.2	21.5	19.0	15.6	72.4
Greasewood	.5	.5	1.0	1.1						
Saltbush	.5	.1	.9	.1						
Winterfat	1.4	.5	1.0	.5			4.2	.6	1.5	2.6
Juniper	Trace	.1	.1	.1						
Pinyon Pine	.5	.1	.7	.1						
Wild Rose	.1	Trace	.1	Trace						
Skunkbush	.5	.4	.6	.3			.4	.4	.2	.5
Deer Days Utilization/Acre	26.6		26.6		28.4		37.2		17.4	
Number of Deer/Acre	.123		.099		.132		.172		.081	

Total Number of Deer: 625

NOTE: (% Available = % Cover; % of Diet = % Species Utilization from Browse Ratings)

Table XI–3 TAGGED SHOOT MEASUREMENTS
FOR DEER SHRUB UTILIZATION. BY HABITAT TYPE

	Pinyon-Juniper			Chained Pinyon-Juniper			Plateau Sagebrush			Valley Sagebrush		
	Artemisia tridentata	Amelanchier alnifolia	Cercocarpus montanus	Art. trid.	Amel. alni.	Cerco. mont.	Art. trid.	Amel. alni.	Cerco. mont.	Art. trid.	Amel. alni.	Cerco. mont.
Mean current year's growth ($\bar{x}_1$)	4.2	5.0	7.6	6.5	–	10.0	3.4	4.9	2.9	5.1	–	–
C.I.* on $\bar{x}_1$	$\bar{x}_1 \pm 0.2$	$\bar{x}_1 \pm 1.9$	$\bar{x}_1 \pm 1.8$	$\bar{x}_1 \pm 1.4$	–	$\bar{x}_1 \pm 4.9$	$\bar{x}_1 \pm 4.9$	$\bar{x}_1 \pm 0.6$	$\bar{x}1 \pm 1.7$	$\bar{x}_1 \pm 2.9$	–	–
Mean growth Remaining after Browsing ($\bar{x}_2$)	0.3	1.6	1.1	1.4	–	2.8	0.5	1.1	0	2.0	–	–
C.I. on $\bar{x}_2$	$\bar{x}_2 \pm 0.2$	$\bar{x}_2 \pm 0.6$	$\bar{x}_2 \pm 0.7$	$\bar{x}_2 \pm 0.6$	–	$\bar{x}_2 \pm 2.0$	$\bar{x}_2 \pm 0.1$	$\bar{x}_2 \pm 3.6$	0	$\bar{x}_2 \pm 2.1$	–	–
Per cent utilization (calculated from means)	93.2	67.0	85.0	79.2	–	72.0	86.0	76.0	100.0	60.0	–	–

Data summarized from pellet group transects.

* 95% confidence interval of the mean.

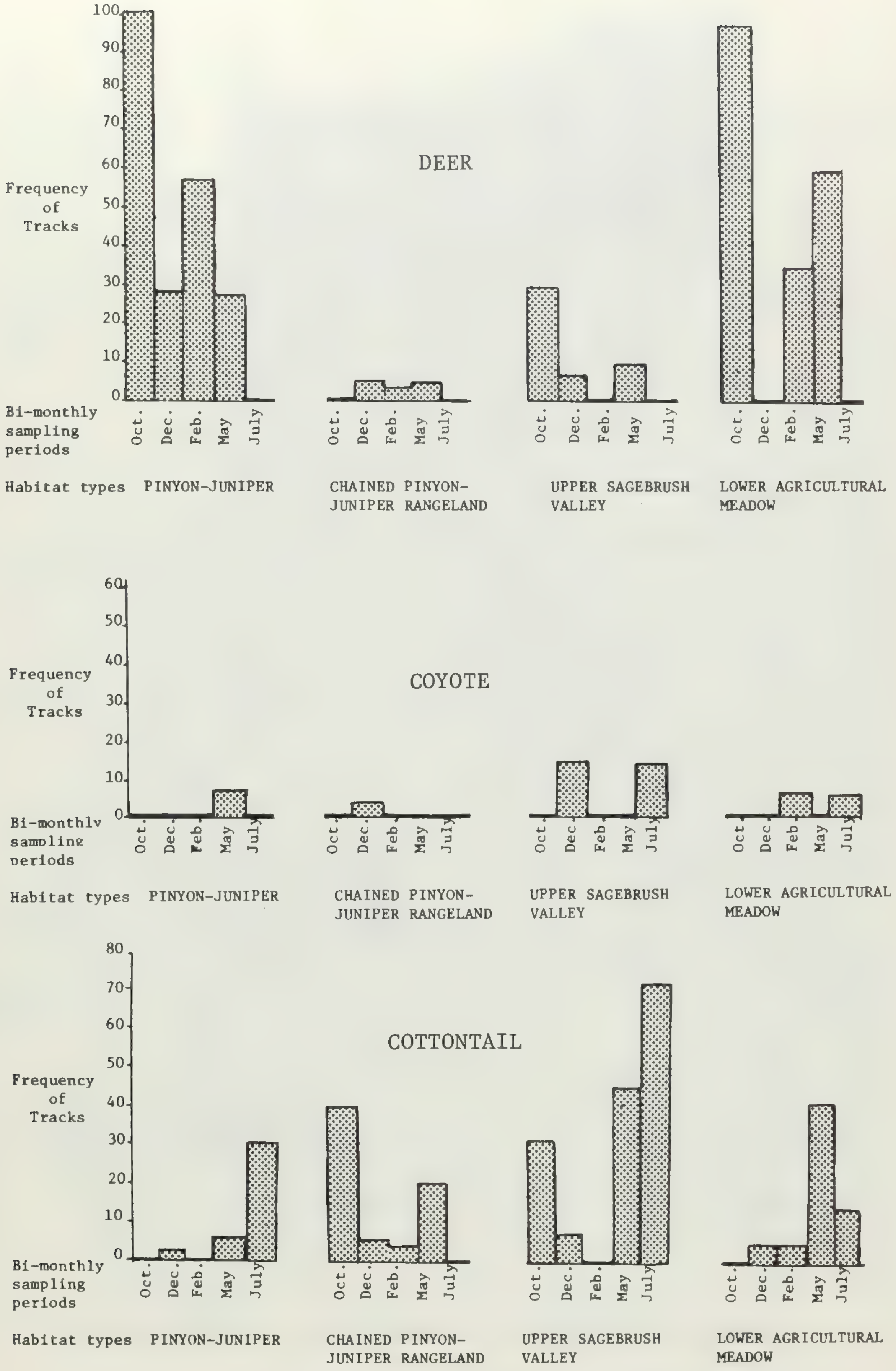


Figure XI–3 SEASONAL OCCURRENCE OF COYOTE, DEER, AND COTTONTAIL BY HABITAT TYPE 1974 - 1975

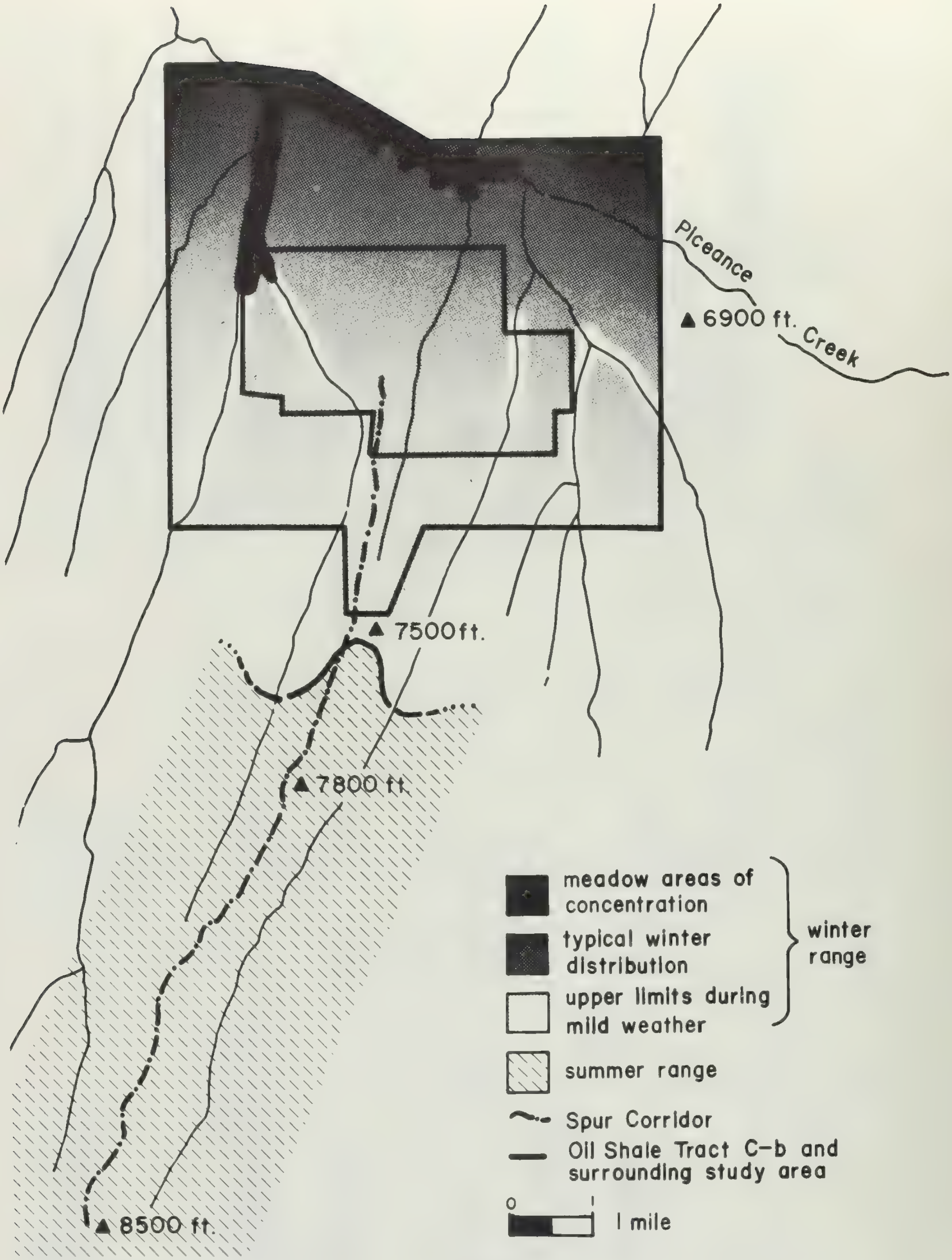


Figure XI–4 WINTER AND SUMMER RANGES OF MULE DEER

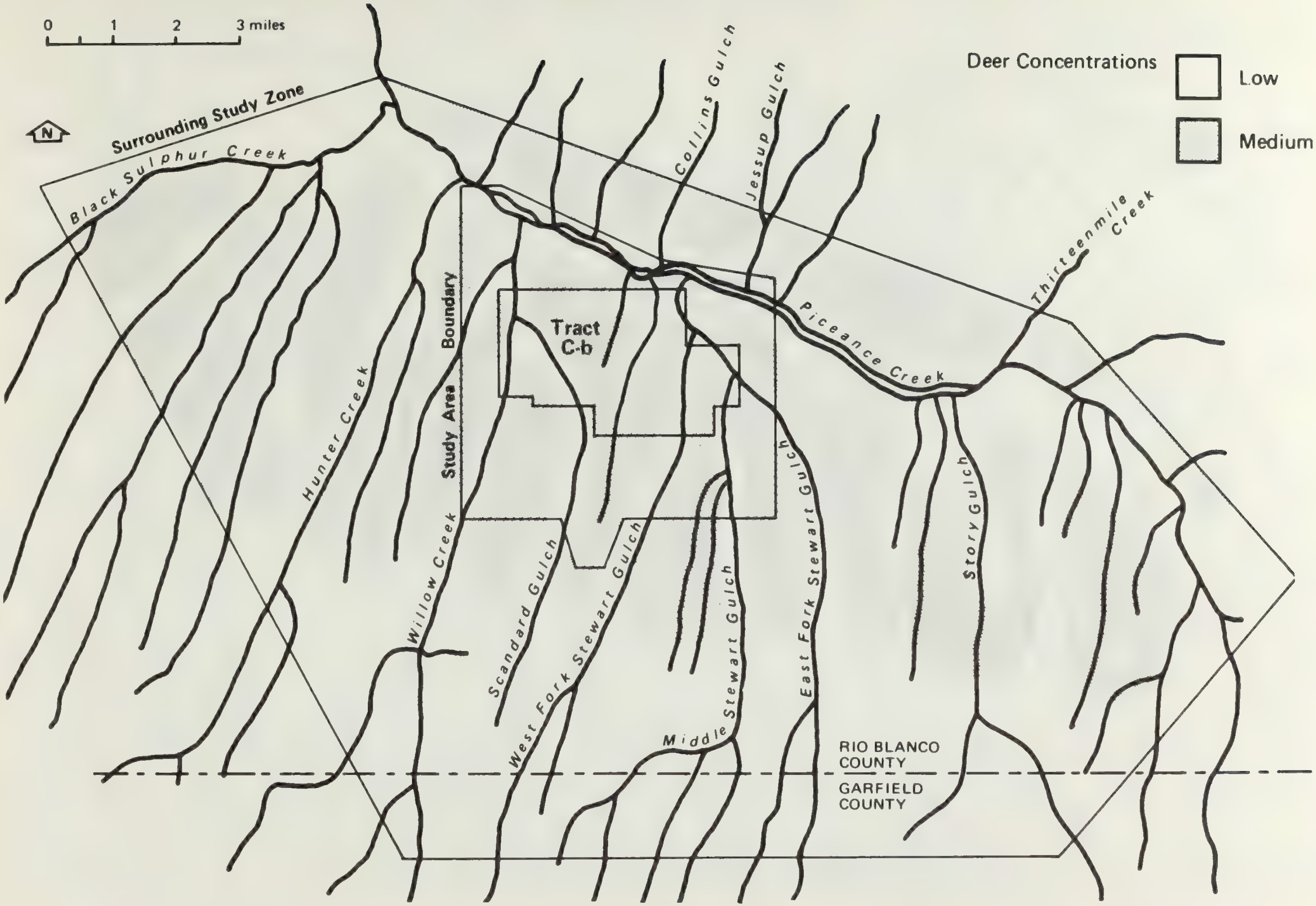


Figure XI–5 LOCAL DISTRIBUTION OF DEER AS DETERMINED BY AERIAL SURVEYS, DECEMBER, 1974

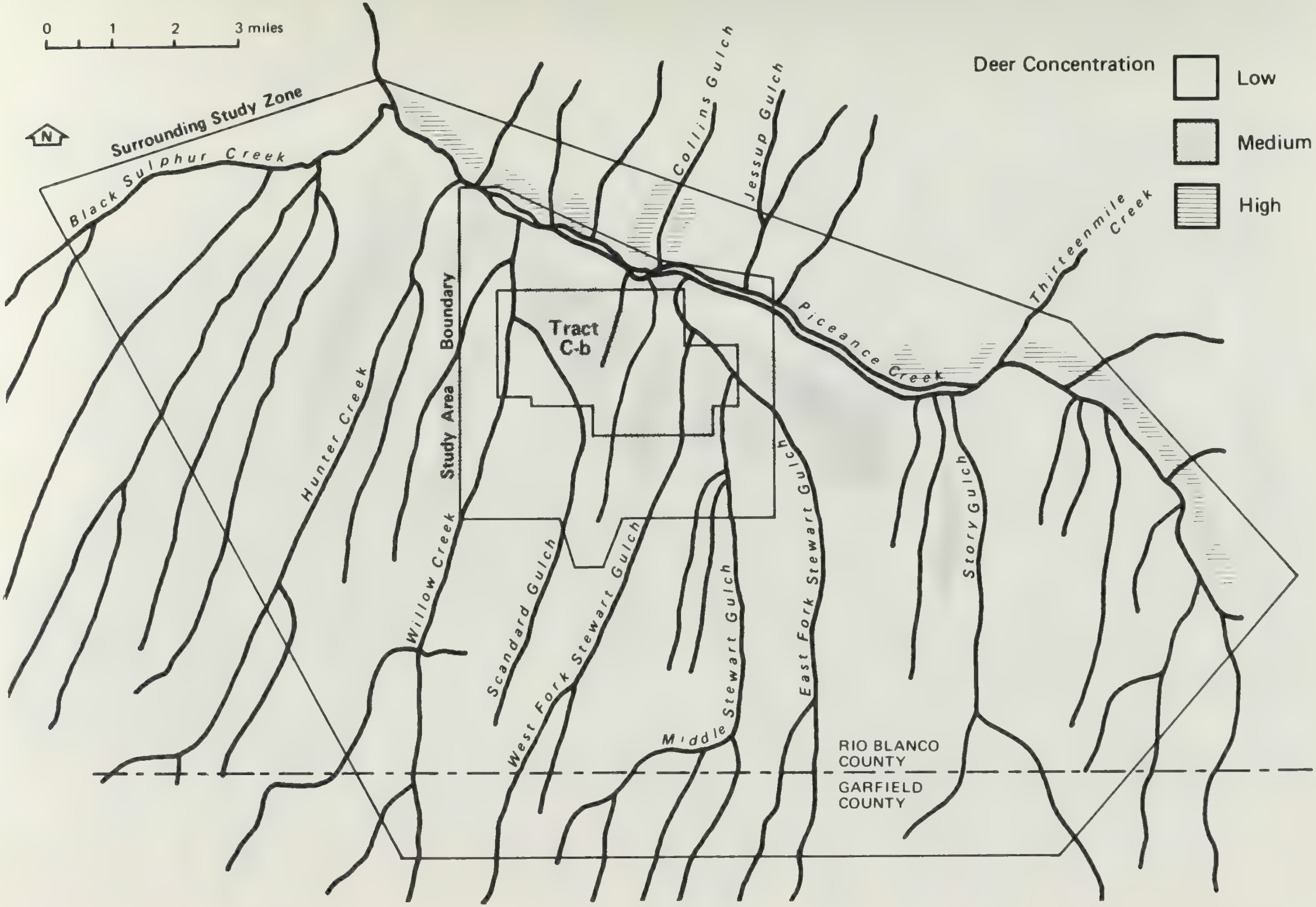


Figure XI–6 LOCAL DISTRIBUTION OF DEER AS DETERMINED BY AERIAL SURVEYS, JANUARY, 1975

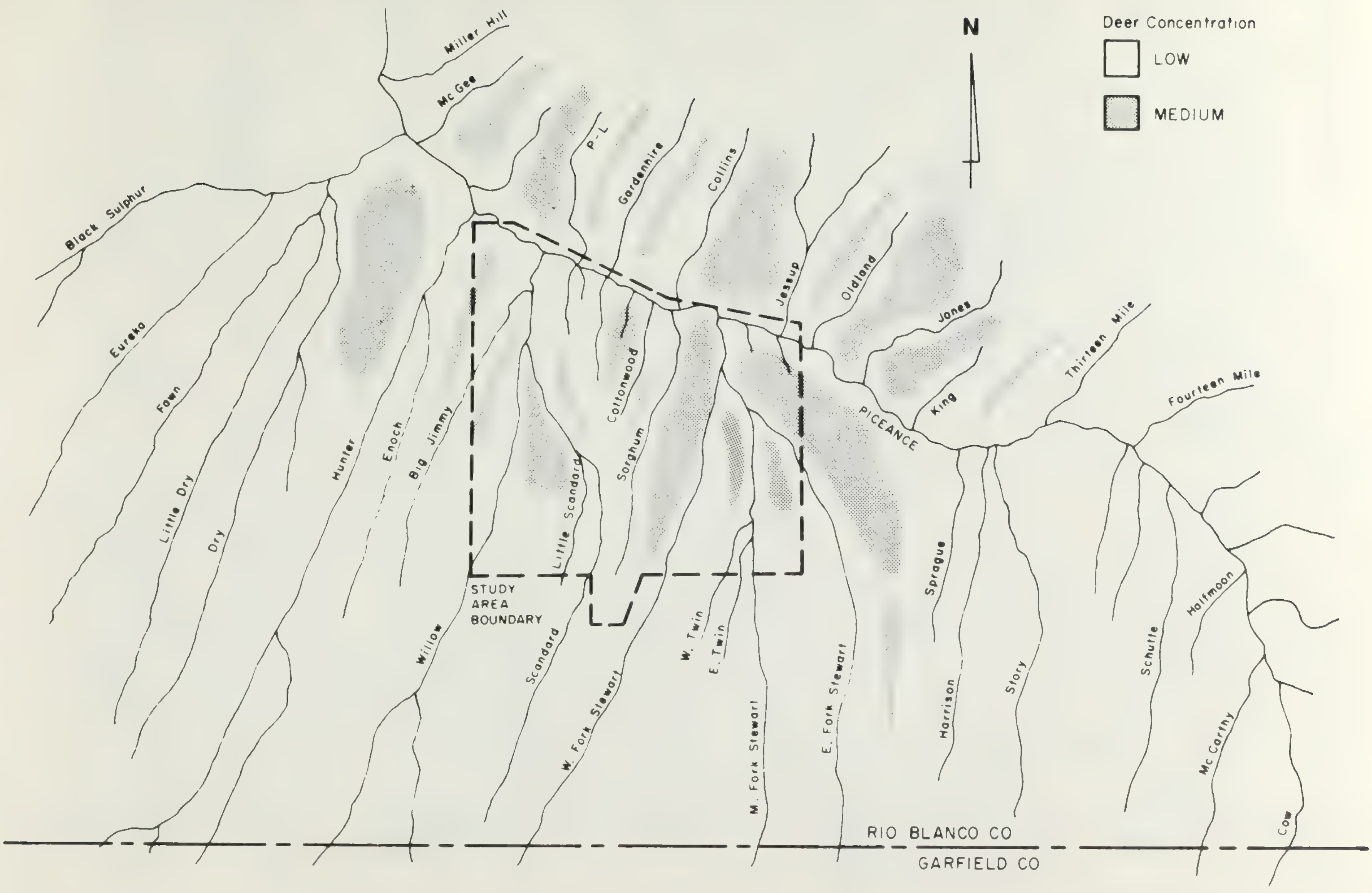


Figure XI–7 LOCAL DISTRIBUTION OF DEER AS DETERMINED BY AERIAL SURVEYS, MARCH, 1975

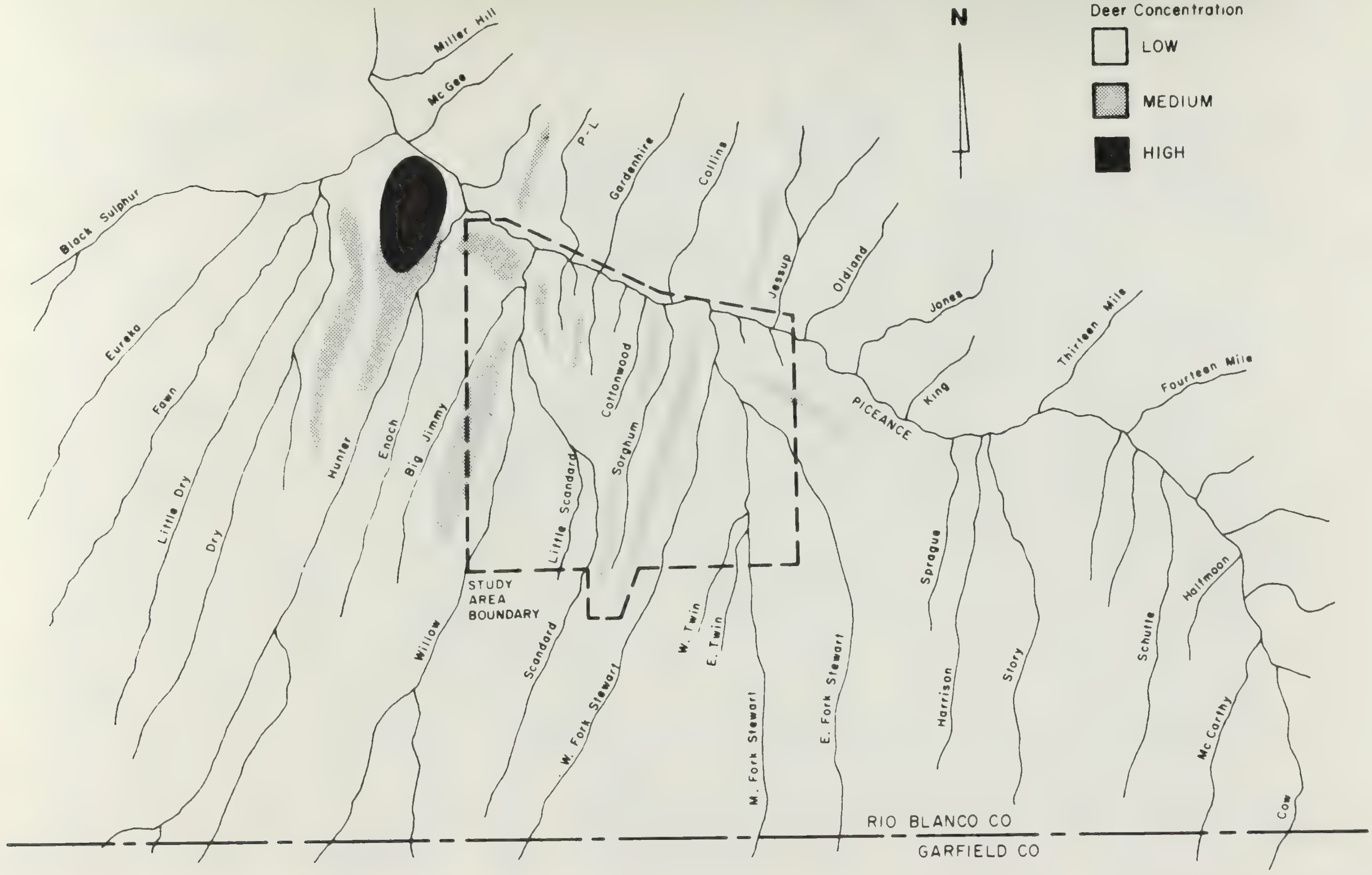


Figure XI–8 LOCAL DISTRIBUTION OF DEER AS DETERMINED BY AERIAL SURVEYS, APRIL, 1975

Meadow concentrations along Piceance Creek occurred generally in the off-tract meadows north and west of the Tract.

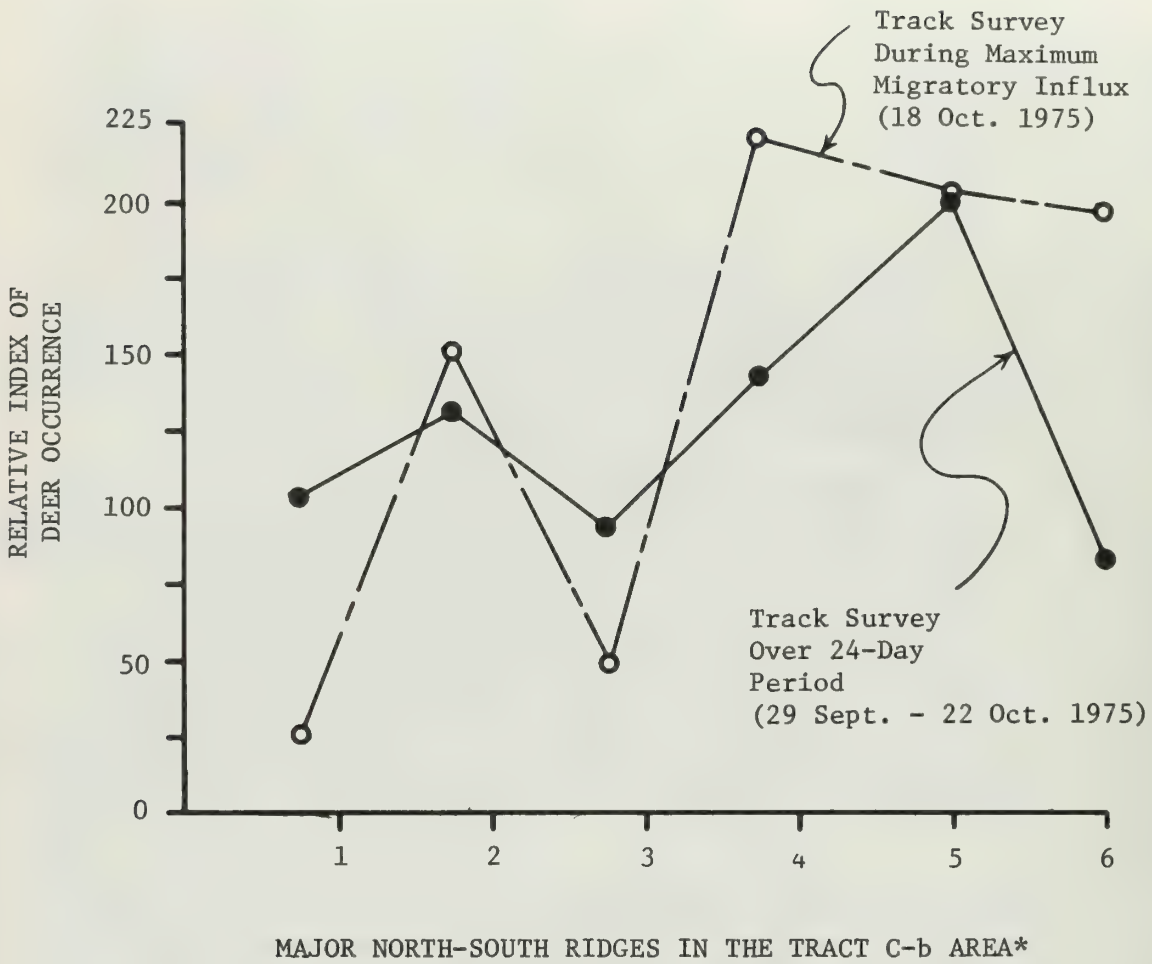
The 1975 fall migratory influx into the Tract area occurred within approximately a one-week period beginning the second week of October. All six of the major north-south ridges studied were used as migratory routes (Figure XI-9). The three ridges which had the highest frequency of tracks were between Willow Creek and Scandard Gulch, between Sorghum Gulch and West Stewart Creek, and between West and Middle Stewart Creek.

During the spring of 1975, deer mortality surveys were performed to evaluate the importance of local areas as deer-wintering range on the Tract and within the surrounding one-mile zone. Large quadrats were located in five habitat types. After the deer had left the Tract in mid-May, deer carcasses were counted within the quadrats. The age of each animal was determined by tooth wear, and in a few cases the cause of death was determined by field observations during the previous winter.

Most of the winter deer mortalities occurred in the small lateral draws of the major north-south drainages, and in the lower valley sagebrush areas immediately adjacent to the agricultural meadows along Piceance Creek (Table XI-4). Very little mortality occurred in the pinyon-juniper woodlands or chained areas. This distribution of deer deaths reflects the importance of local habitat features during times of severe winter weather. The habitat features most important to winter deer survival and consequently the areas sought by deer when physiologically stressed are: (1) the protection from wind afforded by the small valleys; and (2) their proximity to south-facing slopes and lower agricultural meadows which generally remain open and available to the deer during times of deep and crusted snow.

The pellet group survey results have been evaluated in two ways. First, pellet group totals have been combined by major vegetation type for all transects in and around the Tract boundary. Second, pellet groups have been totaled by elevation: (a) for higher elevations south of the Tract, (b) for elevations through the Tract, and (c) for south-facing and exposed lower slopes north of the Tract. Deer-day utilization per acre and deer per acre were calculated by using 216 days as the time interval of major deer inhabitation of the Tract. Table XI-5 lists results from the pellet group surveys.

By evaluating pellet group numbers and deer utilization by major habitat types, it is apparent that the upland sagebrush and chained pinyon-juniper rangeland are important browse areas during the winter. Deer-day utilization per acre was 37.2 and 28.4 respectively for these two habitat types. The least utilization occurred in the valley sagebrush habitat. High utilization may be due to increased cover and accessibility of preferred browse species in the chained pinyon-juniper, and the accessibility of the plateau sagebrush when other feeding areas have more snow accumulation. During the winter, valley sagebrush and pinyon-juniper woodland were utilized to a lesser extent than other vegetation types.



*Ridge 1 = West of Willow Creek
Ridge 2 = Between Willow Creek and Scandard Gulch
Ridge 3 = Between Scandard and Sorghum Gulch
Ridge 4 = Between Sorghum Gulch and West Stewart Creek
Ridge 5 = Between West and Middle Stewart Creek
Ridge 6 = Between Stewart and Piceance Creek

All sampling sites were located on ridges within pinyon-juniper woodland.

Figure XI–9 RELATIVE USE BY DEER OF MIGRATION ROUTES INTO THE TRACT C-b AREA

Table XI–4 DISTRIBUTION OF DEER CARCASSES[1] IN FIVE HABITAT TYPES

Habitat Type	Number of Carcasses Found (No./Acre)	Number of Carcasses Expected If Randomly Distributed	Number of Acres Sampled In Each Habitat[2]
Pinyon-juniper woodland	22 (0.3)	46	79
Chained pinyon-juniper rangeland	7 (0.1)	46	79
Valley sagebrush (6500 ft.)	17 (0.4)	23	40
Lower agricultural meadows and adjacent valley sagebrush	77 (1.0)	46	79
Lateral draws	48 (2.7)	10	18

1 Carcasses are not randomly distributed ($X^2 = 204$; df = 4; $P < .001$).

2 Total area sampled = 119.25 hectares (295 acres).

Table XI–5 RESULTS OF PELLET GROUP SURVEYS
IN AND AROUND TRACT C-b DURING WINTER OF 1974-1975

	Vegetation Type					Elevation		
	Pinyon Juniper	Chained P-J	Plateau Sagebrush	Valley Sagebrush	Tract C-b Study Area	C-b Boundary	Piceance Creek	7100 Elevation
Number pellet groups	1413	532	512	93	2550	1389	758	403
Number of plots	509	144	106	41	800	400	300	100
Total number acres sampled	5.1	1.4	1.1	.41	8	4	3	1
Pellet groups/acre	277.6	369.4	483.0	226.8	345.8	347.2	252.6	403
Mean pellet groups	74.4	76.0	102.4	23.2	72.8	173	126	202
Confidence Interval on Mean	±27.6	±68.7	±75.6	±15.3	±20.5	±56.3	±36.9	±88.4
Deer days utilization/acre	21.4	28.4	37.2	17.4	26.6	26.7	19.4	31
Number of Deer/acre	.099	.132	.172	.081	.123	0.124	0.09	0.144

Pellet group counts indicated that approximately 625 deer wintered in the Tract area. This number is based on the assumption that the population was stable during this winter period. Road count and mortality data showed an approximate 40% decline in the fawn population during the winter; therefore, the winter population of 625 is probably overestimated.

Based on pellet group numbers, deer-day per acre is highest at the higher elevation at the south end of the Tract (31 deer-days), followed by 26.7 deer-days per acre on the Tract, and 19.4 deer-days per acre on the lower exposed slopes north of the Tract. Although observation suggests heavy utilization of these lower south-facing slopes in late winter and early spring, such utilization may occur for a relatively short period of time.

Several plant species, including big sagebrush, mountain mahogany, bitterbrush and serviceberry, are important as winter forage for mule deer. Within each pellet group transect, 14 plant species were rated in terms of relative cover and degree of browsing. Table XI-2 shows results for the Tract study area and for each major vegetative type. Big sagebrush represents 80% of the vegetation cover available to mule deer for browsing in the valley sagebrush type, 68% in the upland sagebrush type, 54% in the chained pinyon-juniper type, and 36% in the pinyon-juniper type. Tract-wide, 51% of the shrub cover available to deer for browsing is represented by big sagebrush; 34% by rabbitbrush, antelope bitterbrush, serviceberry, and mountain mahogany; and 15% by nine additional species, with 10% snowberry.

The percent of diet (which is referred to as utilization) is computed by multiplying relative cover values by degree of browsing values and expressing in terms of percentages. Percent of diet is thus a measure of the relative use of the shrubs. For example, in the valley sagebrush, 24% of the diet (80% cover x 0.30 for moderate browsing = 24%) is sagebrush, in spite of the fact that 80% of the browse cover consists of big sagebrush. That is, sagebrush available for consumption is lightly to moderately utilized. Rabbitbrush, on the other hand, makes up approximately 16% of the shrub cover and is heavily utilized (72.4% of diet). Shrub species which are utilized in percentages above their availability are generally heavily hedged and in poor to fair condition.

Table XI-2 shows that based on one year's data big sagebrush and rabbitbrush are the most important browse species on the Tract (45% and 15% of diet respectively). Antelope bitterbrush, serviceberry and mountain mahogany are also important browse species since combined they account for 32% of the winter diet, and their utilization is greater than their availability. These three species were all moderately to severely hedged in all transects. The remaining nine shrub species represent 7% of the winter diet.

Because the Tract is grazed by cattle during portions of the year, under the control of the Bureau of Land Management, some competition between deer and cattle on the Tract exists. The amount of competition

is dependent on the area and number of forage species browsed or grazed in common and also on the period of time which each animal species utilizes the Tract. The distribution and abundance of both deer and cattle on the Tract are determined by direct observation and the presence of deer pellet groups and cow droppings in established transects. In addition, numbers of cattle potentially utilizing the area are determined through BLM records of grazing allotments. Over 7000 head of cattle graze the common allotment that includes the Tract. Six hundred fifty animal unit months (AUMS) of feed are produced on the Tract, according to the U. S. Department of the Interior.

Deer occupy the Tract and surrounding area from approximately September through May, depending on climatic conditions, as has been discussed above. Cattle, on the other hand, utilize the allotment area (which includes Tract C-b) from April to October. It appears that the present pattern of use has been established to avoid the probability of large numbers of deer and cattle occupying Tract C-b simultaneously. Indirect competition may exist, however, if cattle utilize forage which then becomes limiting or unavailable to deer. During severe winter periods any significant decrease in range carrying capacity caused by cattle grazing could result in increased winter mortalities due to malnutrition and attendant problems.

The pattern of cattle use on Tract C-b was observed from August, 1974 through September, 1975, and is summarized here. After wintering away from Piceance Creek in wintering pens, the cattle are released to graze in the hay meadows in early spring. As the growing season progresses, the cattle move away from the hay meadows, pass through Tract C-b, and summer at higher elevations south of the Tract. At any one time few cattle are grazing on Tract C-b. It appears, therefore, that the Tract is little utilized by cattle during the growing season. Productivity measurements for the herbaceous layer in 1975 support this conclusion. There appears to be no significant difference in production between cattle exclosures and plots open to grazing at the vegetation study sites. This would imply that no significant cattle grazing takes place on Tract C-b during the growing season.

As winter approaches the cattle move away from the summer range, pass through Tract C-b, and utilize the hay meadows extensively. Again, during this time a small number of cattle passing through graze on the Tract. After November, 1974 and October, 1975, few cattle, if any, were utilizing the Tract. From one year's observations it appears that deer utilize the Tract heavily from October to May; and cattle utilize the tract very lightly in the spring and fall, and are virtually absent in June, July and August.

c. Medium-sized Mammals

The medium-sized mammals identified on the Tract are badger, beaver, bobcat, coyote, desert cottontail, muskrat, porcupine, raccoon, striped skunk and white-tailed jackrabbit. The gray fox and yellow-bellied

marmot have been identified in the near vicinity.

Most of the above species are discussed in the section on predators (Section XI. B. 1. a.). Of the remaining species - the porcupine, muskrat and beaver - only brief mention can be made of their general abundance and habitat occurrence.

The porcupine is common to the south of the Tract, and most frequently occurs in the mixed mountain shrub in close proximity to aspen groves. On the Tract, porcupines are uncommon, although they have been observed in the pinyon-juniper and mixed mountain shrub habitat types.

Muskrats are common in Piceance Creek and in the nearby ponds and irrigation ditches. They tend to be most numerous in areas with appreciable riparian vegetation, especially cattails and bullrushes. Fragments of muskrat bones have been found high among the rimrock where the animal was likely carried and fed upon by a great horned owl.

Beaver are rare on and near the Tract. Beaver ponds located approximately 10 miles upstream were inhabited in the summer and fall of 1974. This area, however, was apparently not used by beaver the following summer. No active dens, lodges or beaver ponds presently occur on the Tract or within the one-mile surrounding zone. Only one sighting has been made of a beaver within this area.

d. Small Mammals

Small mammals on the Tract include shrews, ground squirrels, chipmunks, gophers, wood rats, mice and voles. They are relatively abundant throughout the Tract and are being studied both quantitatively and qualitatively by the use of live and snap traps. Because approximately 83% of the Tract is represented by pinyon-juniper woodland and chained pinyon-juniper rangeland, two large grids (one in each habitat type) have been established to determine population densities of small mammals in these habitats. The effective trapping area of each grid is 6.94 acres (2.21 hectare). From May through September/October, small mammals on these grids are trapped in 3 to 10-day periods each month. Captured animals are permanently marked. Species name, reproductive condition, life history stage, sex, live weight (May and September) and presence of parasites are recorded and the animal is released alive. Away from the trapping grids, snap trap lines are set to capture small mammals for reproductive and food habit determinations in the laboratory, and satellite grids are located for qualitative live-trapping. The two large quantitative grids and the qualitative satellite grids are discussed below and shown in Figure XI-1.

Grid #1 is in a chained pinyon-juniper rangeland, characterized by fallen pinyon and juniper trees. Dominant species of shrubs and grasses are big sagebrush, snowberry, rabbitbrush, crested wheatgrass and Indian ricegrass. Grid #2 is located in a mature stand of pinyon-juniper woodland and the understory is big sagebrush, mountain mahogany, service-

berry, antelope bitterbrush and prickly pear cactus.

Trapping results from the two quantitative grids for the year August 1974 - August 1975 reveal that the species numbers and species composition are similar in both habitats. Eleven species have been captured at Grid #1, and 6 species at Grid #2 (see Table XI-6). A total of 325 individuals have been marked at Grid #1, the chained site. Forty percent (129 individuals) of the total marked animals were the deer mouse (Peromyscus maniculatus), 37% (121) were the least chipmunk (Eutamias minimus), and 11% (37) were the montane vole (Microtus montanus). At the pinyon-juniper woodland site (Grid #2), of 232 animals marked, the distribution included 68% (145) deer mice and 28% (64) least chipmunks.

Qualitative satellite live-trapping grids are located in other vegetation types in the Tract vicinity (see Figure XI-1). These other vegetation types include riparian, agricultural meadows, mountain shrub and sagebrush-rabbitbrush located in the valleys, plateaus and canyon mouths. Trapped animals are identified, and sex, age and reproductive condition recorded. This information is used to determine species composition and relative abundance for each satellite grid. Of 704 individuals captured at the satellite grids, the distribution included 62% deer mice and 22% least chipmunks. Three additional small mammal species not captured in Grids #1 and #2 have been captured in the satellite grids (Table XI-6). These include Richardson's ground squirrel, the western jumping mouse and an additional vole species. Including these three species, a total of 16 small mammal species have been identified on the Tract.

When total marked individuals on the large grids are compared with total captures on the satellite grids, results indicate that the two most important species on the Tract in terms of relative abundance are the deer mouse and the least chipmunk.

Comparative studies of the biology of the deer mouse and the least chipmunk have been carried out on both large grids. Details of these studies are discussed below:

-- Grid #1 - Chained Pinyon-Juniper Site

For the year August 1974 through August 1975 a total of 1595 individuals have been captured over 2600 trap-nights representing a 61.3% trapping success. In terms of population estimates for all species, it is apparent that seasonal fluctuations result particularly in sub-adult animals (Figure XI-10 and Table XI-7). Spring and summer lows are followed by late summer highs.

Seasonal activity is exhibited in all small mammals, and is influenced by climatic conditions. The Apache pocket mouse, ground squirrels and chipmunks hibernate or become inactive in the winter. As temperatures increase in spring, they resume intermittent activities, depending on

Table XI–6 SMALL MAMMAL SPECIES CAPTURED ON OR NEAR TRACT C-b

SPECIES	MAJOR GRIDS*		SATELLITE GRIDS**								
	1	2	1	2	3	4	5	6	7	8	9
Sorex vagrans	x				x						
Sorex cinerea	x										
Spermophilus lateralis	x	x		x	x		x	x			x
Spermophilus richardsoni						x					
Eutamius minimus	x	x		x	x	x	x	x	x		x
Eutamius quadrivittatus	x	x		x		x	x	x			x
Thomomys talpoides	x		x								
Perognathus apache	x	x		x				x	x	x	
Microtus montanus	x	x	x		x	x	x	x	x		
Microtus pennsylvanicus			x								
Microtus longicavdus	x		x			x	x				
Lagurus curtatus	x			x		x		x		x	
Neotoma cinerea	x	x		x	x			x			
Peromyscus maniculatus	x	x	x	x	x	x	x	x	x	x	x
Peromyscus truel	x										
Zapus princeps			x								

*Location - Major Grids	Habitat Type
(1) Near Met. Tower	Chained Pinyon-Juniper
(2) West/Middle Stewart Ridge	Pinyon-Juniper

**Location - Satellite Grids	Habitat Type
(1) Piceance Creek	Riparian/Willow-Hay Meadow
(2) West Stuart Creek	Valley Sagebrush/Rabbitbrush
(3) Tract Entrance Road	Mesa/Chained Pinyon-Juniper Mountain Shrub
(4) Lower Sorghum Gulch	Canyon Mouth/Sagebrush-Rabbitbrush
(5) Middle Sorghum Gulch	Canyon/Pinyon-Juniper-Mountain Shrub
(6) Upper Sorghum Gulch	Canyon/Grass-Mountain Shrub
(7) Lower Cottonwood Gulch	Canyon Mouth/Sagebrush-Rabbitbrush
(8) Willow Creek	Pond/Sagebrush-Alfalfa
(9) Grid 2 Satellite	Hilltop/Pinyon-Juniper-Mountain Shrub

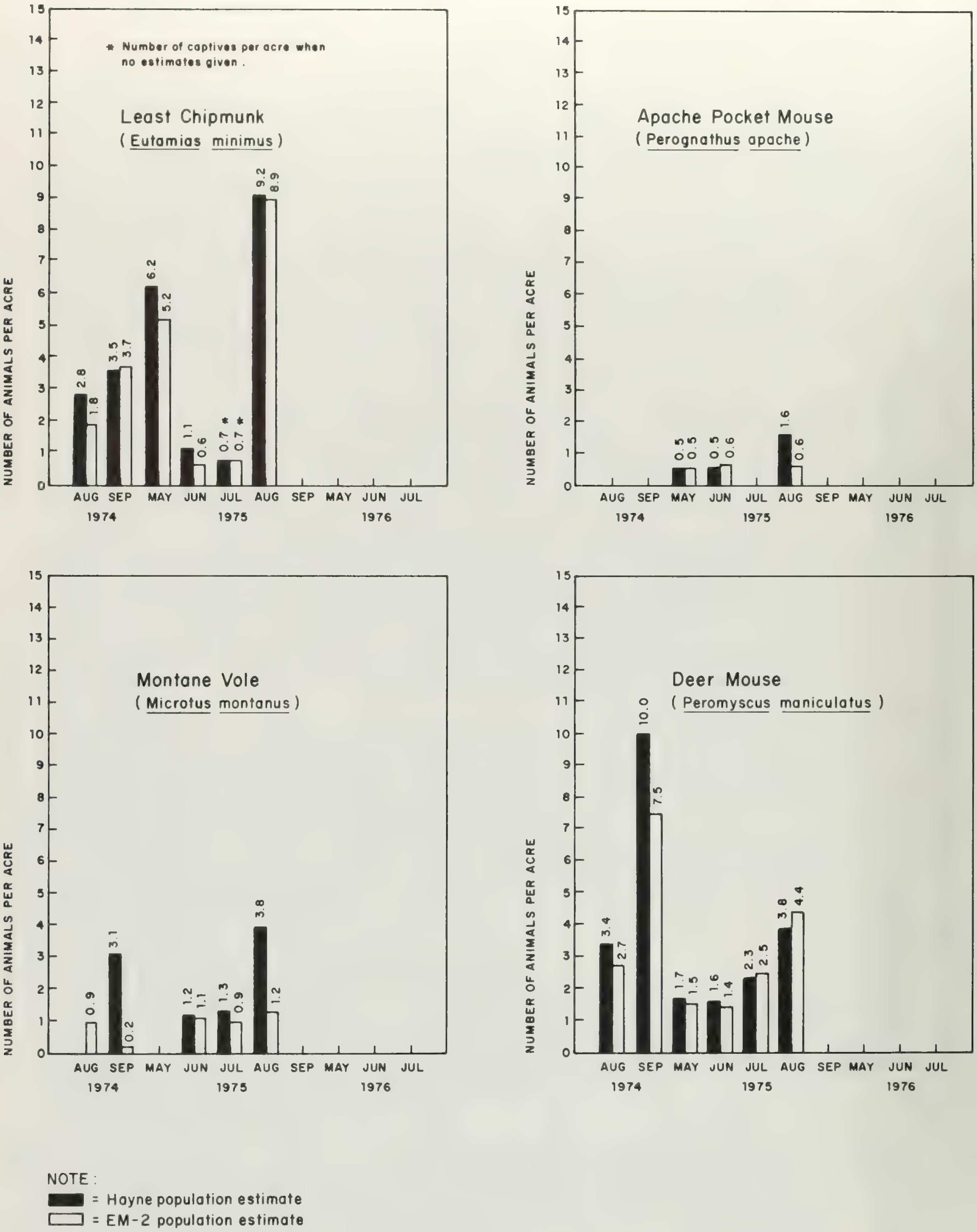


Figure XI—10 SEASONAL DENSITY ESTIMATES FOR SMALL RODENTS ON TRACT C-b, GRID #1

Table XI–7 POPULATION ESTIMATES[a] FOR SMALL MAMMAL SPECIES ON GRIDS 1 AND 2, AUGUST, 1974 TO AUGUST, 1975

Species	August		September		May		June		July		August	
	Grid 1	Grid 2	Grid 1	Grid 2	Grid 1	Grid 2	Grid 1	Grid 2	Grid 1	Grid 2	Grid 1	Grid 2
Peromyscus maniculatus	22.3[b] / 18.4	36.4 / 30.4	60.0 / 43.4	63.8 / 50.9	9.3 / 15.5	3.9 / 3.6	9.0 / 7.2	15.3 / 3.9	13.5 / 14.3	10.5 / 5.9	25.3 / 25.6	18.1 / 18.4
Eutamius minimus	18.1 / 12.1	14.8 / 1.9	24.2 / 20.4	23.7 / 16.1	31.1 / 32.0	9.4 / 3.3	6.2 / 6.1	5 [c] / 5	5 [c] / 5	13 / 8.3	56.9 / 52.6	46.0 / 33.3
Perognathus apache					1.8 / 2.1		3.6 / 3.6				17.9 / 7.7	
Microtus montanus	1.7 / 1.5		13.0 / 0.6		1.0[c] / 1.0		6.7 / 6.3		10.4 / 8.6		22.2 / 8.0	1 [c] / 1
Neotoma cinerea			3.6 / 0.9							2 [c] / 2		1 [c] / 1
Eutamius quadrivittatus			0.5[c] / 0.5			1.2 / 1.2		4 [c] / 4		3 [c] / 3		4 [c] / 4
Spermophilus lateralis					3.0 / 2.5		1.0 / 1.0		8.0 / 8.0	3 [c] / 3	4.0 / 4.0	2 [c] / 2
Totals	42.1 / 32.0	51.2 / 32.3	101.3 / 65.8	87.5 / 67.0	46.2 / 53.1	14.5 / 8.1	26.5 / 24.2	24.3 / 12.9	36.9 / 35.9	31.5 / 22.2	126.3 / 97.9	72.1 / 59.7

a - Total number of individuals estimated on the 10 x 10 grid – animals per hectare can be calculated by dividing the given estimate by 2.8 - animals per acre can be calculated by dividing the given estimate by 6.94.

b Hayne estimate / EM-2 estimate

c - Number captured on grid when no estimate is given by computer program.

climatic conditions. In contrast, the deer mouse and the vole are active throughout the winter and do not hibernate. Relative seasonal activity, shown in Figure XI-11, is represented by trap success statistics for Grid #1.

-- Density

Deer mice are the most abundant animals on the Tract. This species exhibits both seasonal and annual fluctuations in numbers. Averaging both density estimates (Hayne and EM-2), it is found that deer mice per hectare were 7.3 in August 1974. The following month mean density had increased to 18.5 per hectare. In winter, when predation and cold weather produce increased stresses on the population the numbers decline as evidenced by the May 1975 average of 4.4 deer mice per hectare. By the end of August 1975 mean density was 9.1 per hectare, approximately 1/3 of the level of September 1974. Table XI-7 summarizes density estimates for the deer mouse for the first year of study.

Estimates fluctuate over the summer months. Inclement weather, particularly rain and low temperatures, appear to curtail small mammal activity. During the May, June and July trapping periods, irregular weather may have influenced trap success.

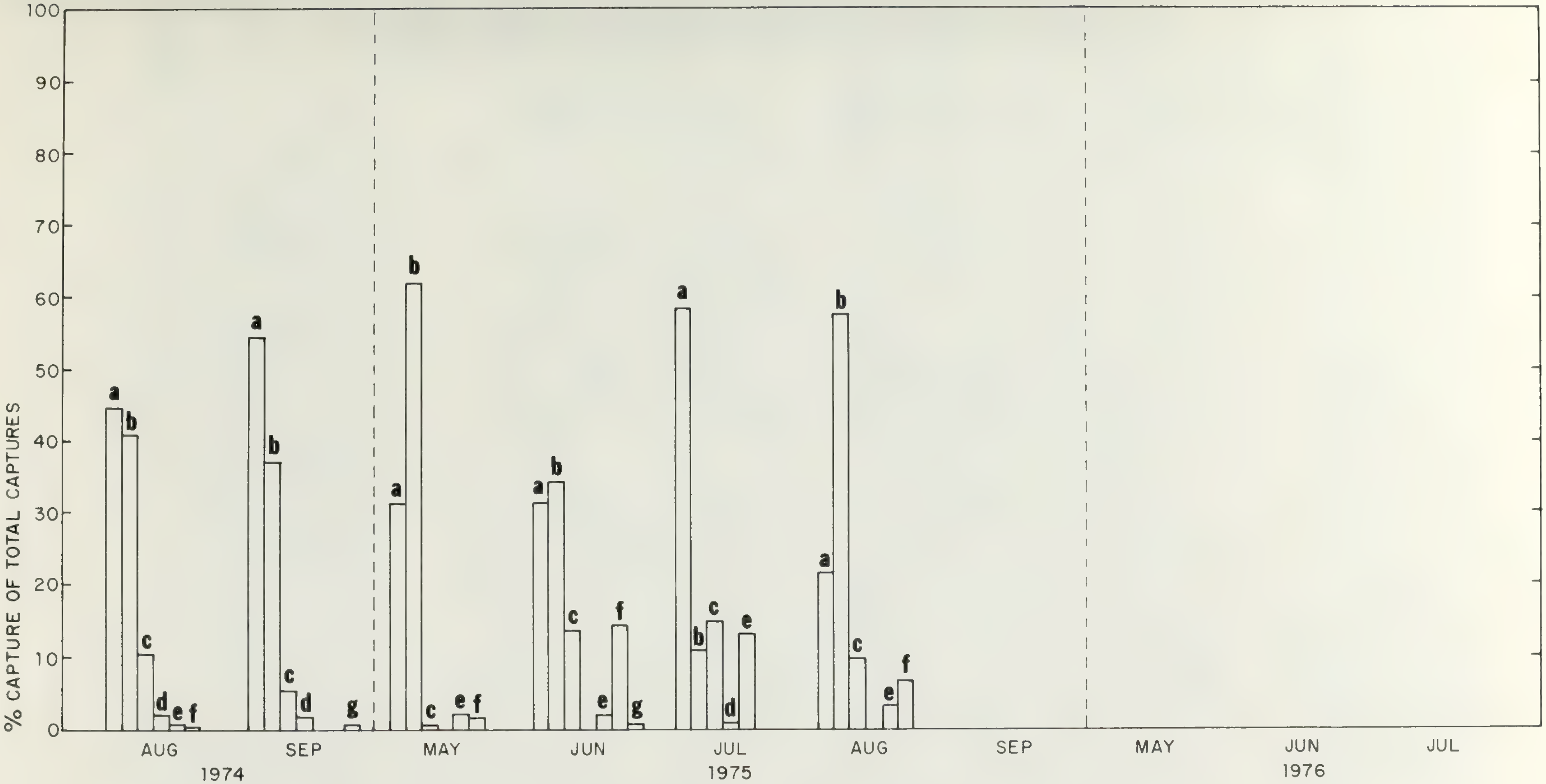
The least chipmunk is the second most abundant mammal in the chained site. Its population densities fluctuate seasonally and yearly (Figure XI-10). For example, population estimates ranged from 5 individuals in July to 56.9 individuals in August 1975 (Hayne estimate). The EM-2 populations estimates ranged from 5 animals in July to 52.6 animals in September 1975.

The least chipmunk population, like the deer mouse, fluctuated over the first year. But the May 1975 density estimate (10.7/hectare) was higher than the September 1974 estimate (6.3/hectare). This could result from a combination of low winter mortality due to relative winter inactivity of this species, and additional recruitment of subadults into the population after the September 1974 survey. Winter mortalities are probably not significant since this species is relatively inactive over the winter.

Of the animals marked during the year, there were more than twice as many remaining least chipmunks as there were deer mice. This indicates that the least chipmunk may have a higher survival rate.

-- Recapture Success

Recapture success influences the population estimate, and is a measure of turn-over rate and longevity. It is also an indicator of behavior patterns in the trappable species. During August and September 1974, 77 deer mice were marked on the chained site. Only six of these were subsequently recaptured. One major cause for the low recapture rate could be mortality, since only 52 new animals were marked from May to August 1975, and their combined recapture success was 32%. The turnover rate is rapid in small animals and these findings are not unusual.



KEY:

a = Peromyscus maniculatus
b = Eutamias minimus
c = Microtus montanus
d = Neotoma cinerea
e = Citellus lateralis
f = Perognathus apache
g = Eutamias quadrivittatus

Figure XI–11 RELATIVE SEASONAL ACTIVITY OF SMALL RODENTS ON TRACT C-b, GRID #1

During August and September 1974, 48 least chipmunks were marked and released. Twelve marked individuals, or 25%, were recaptured in the spring and indicated a 75% reduction in the marked population. It is clear that winter inactivity enhances winter survival. Average recapture success from May through July for the least chipmunk is very similar to that of the deer mouse (8.6% vs. 10.0%). This implies that environmental factors influence both species.

-- Biomass

During September 1974, live weights were determined for 44 deer mice tract-wide, and a total of 462.6 gms/acre of deer mice was calculated by multiplying the average number of individuals/hectare by the average rodent live weight. May 1975 live weights were determined for 28 deer mice. The sample size for reproductive females was small but there is evidence that reproductive females weigh more than non-reproductive females. A total of 88.6 gms/acre of deer mice was calculated from the May sampling, which represents approximately 20% of the original biomass, or an 80% loss in biomass over the winter for this species.

September 1975 live weight determinations were from 19 animals. Reproductive females again showed an average increase over non-reproductive females. Biomass showed a 70% gain over May 1974 estimates but still represented only approximately 27% of the September 19th biomass. Live weight or biomass estimates are given in Table XI-8.

Forty-eight chipmunks were marked in August and September 1974. The live weights for chipmunks in September 1974 include both the least chipmunk and the Colorado chipmunk. Twenty-two chipmunks were examined. and an average of 6.7 chipmunks/hectare occurred on the chained site during this time. Total chipmunk biomass was 285.3 gms/hectare in September 1974.

In May 1975, live weight determinations of least chipmunks were made. Total biomass was 469.5 gms/hectare representing a 60% increase in biomass over September 1974. During September 1975, 21 animals were examined for a total least chipmunk biomass of 276.3 gms/hectare. The greatest biomass of chipmunks occurred in May 1975.

-- Reproductive Activity

Reproductive periods for most small mammals peak in the spring and continue with varying intensity through summer with an occasional late summer peak. These reproductive periods are influenced by the primary production of the vegetation. In August 1974, 5% of the female population was in reproductive condition (lactating, pregnant or estrus). During September there was no indication of reproductive activity. In May 1975, at the start of the spring trapping period, 85% of the males and 26% of the females were reproductive. The percentage for males dropped over the summer, but the females' percentage continued to increase and reached a peak in August. Figure XI-12 shows percentage reproductions in Grid #1

Table XI–8 LIVE WEIGHTS OF SMALL MAMMALS TRAPPED ON GRIDS 1 & 2, CHAINED PINYON-JUNIPER AND PINYON-JUNIPER DURING SEPTEMBER 1974, MAY 1975 AND SEPTEMBER 1975[1]

		Deer Mouse (Peromyscus maniculatus)			Least Chipmunk (Eutamias minimus)			Colorado Chipmunk (Eutamias quadrivittatus)		
		Sept. 1974	May 1975	Sept. 1975	Sept. 1974	May 1975	Sept. 1975	Sept. 1974	May 1975	Sept. 1975
Grid 1	ADULT MALES									
	Number weighed	0	9	8	1	36	16			
	Mean Weight, $\bar{x}$, grams	–	21.7	15.5	38	32.9	32.7			
	Range	–	17.0-27.0	11.0-21.0	–	28.0-44.5	30.0-36.0			
	Standard Deviation	–	4.0	3.9	–	4.3	1.9			
	95% Confidence Interval	–	$\bar{x} \pm 3.1$	$\bar{x} \pm 3.4$	–	$\bar{x} \pm 1.5$	$\bar{x} \pm 1.0$			
	ADULT FEMALES (Non-reproductive)									
	Number weighed	0	16	6	0	30	5			
	Mean Weight, $\bar{x}$, grams	–	20.2	14.5	–	33.7	33.6			
	Range	–	15.5-26.5	12.0-21.0	–	21.5-40.0	30.0-37.0			
	Standard Deviation	–	3.5	3.6	–	3.8	2.5			
	95% Confidence Interval	–	$\bar{x} \pm 1.9$	$\bar{x} \pm 3.8$	–	$\bar{x} \pm 1.4$	$\bar{x} \pm 3.1$			
	ADULT FEMALES (Reproductive)									
	Number weighed	0	3	5	0	20	0			
	Mean weight, $\bar{x}$, grams	–	24.7	19.4	–	41.9	–			
	Range	–	23.0-27.5	14.0-29.0	–	26.5-53.0	–			
	Standard Deviation	–	2.5	5.8	–	6.8	–			
	95% Confidence Interval	–	$\bar{x} \pm 6.2$	$\bar{x} \pm 7.2$	–	$\bar{x} \pm 3.2$	–			
Grid 2	ADULT MALES									
	Number weighed	24	11	17	8	11	1	7	7	1
	Mean Weight, $\bar{x}$, grams	23.0	21.7	14.3	42.2	31.5	24.0	53.6	52.4	50.0
	Range	10.0-30.0	18.0-25.0	9.5-21.0	35.0-55.0	29.0-34.0	–	45.0-70.0	43.0-58.0	–
	Standard Deviation	4.8	2.3	3.4	7.5	1.9	–	5.0	5.1	–
	95% Confidence Interval	$\bar{x} \pm 2.0$	$\bar{x} \pm 1.5$	$\bar{x} \pm 1.7$	$\bar{x} \pm 6.3$	$\bar{x} \pm 1.3$	–	$\bar{x} \pm 7.4$	$\bar{x} \pm 4.7$	–
	ADULT FEMALES (Non-reproductive)									
	Number weighed	16	3	11	6	7	0	1	0	0
	Mean Weight, $\bar{x}$, grams	19.2	19.0	13.5	35.7	36.6	–	50.0	–	–
	Range	10.0-30.0	17.0-22.0	9.0-20.0	32.0-40.0	32.0-41.0	–	–	–	–
	Standard Deviation	4.8	2.6	3.1	2.6	3.2	–	–	–	–
	95% Confidence Interval	$\bar{x} \pm 2.6$	$\bar{x} \pm 6.5$	$\bar{x} \pm 2.1$	$\bar{x} \pm 2.7$	$\bar{x} \pm 3.0$	–	–	–	–
	ADULT FEMALES (Reproductive)									
	Number weighed	0	8	1	0	5	0	0	6	0
	Mean Weight, $\bar{x}$, grams	–	21.3	21.0	–	34.2	–	–	59.7	–
	Range	–	18.5-25.0	–	–	30.0-39.5	–	–	56.0-65.0	–
	Standard Deviation	–	2.4	–	–	3.1	–	–	3.1	–
	95% Confidence Interval	–	$\bar{x} \pm 2.0$	–	–	$\bar{x} \pm 3.8$	–	–	$\bar{x} \pm 3.3$	–

1 Biomass estimates given in text are computed by multiplying the average number of individuals/hectare (Table XI–7: population estimate divided by appropriate conversion factor) by the average rodent live weight.

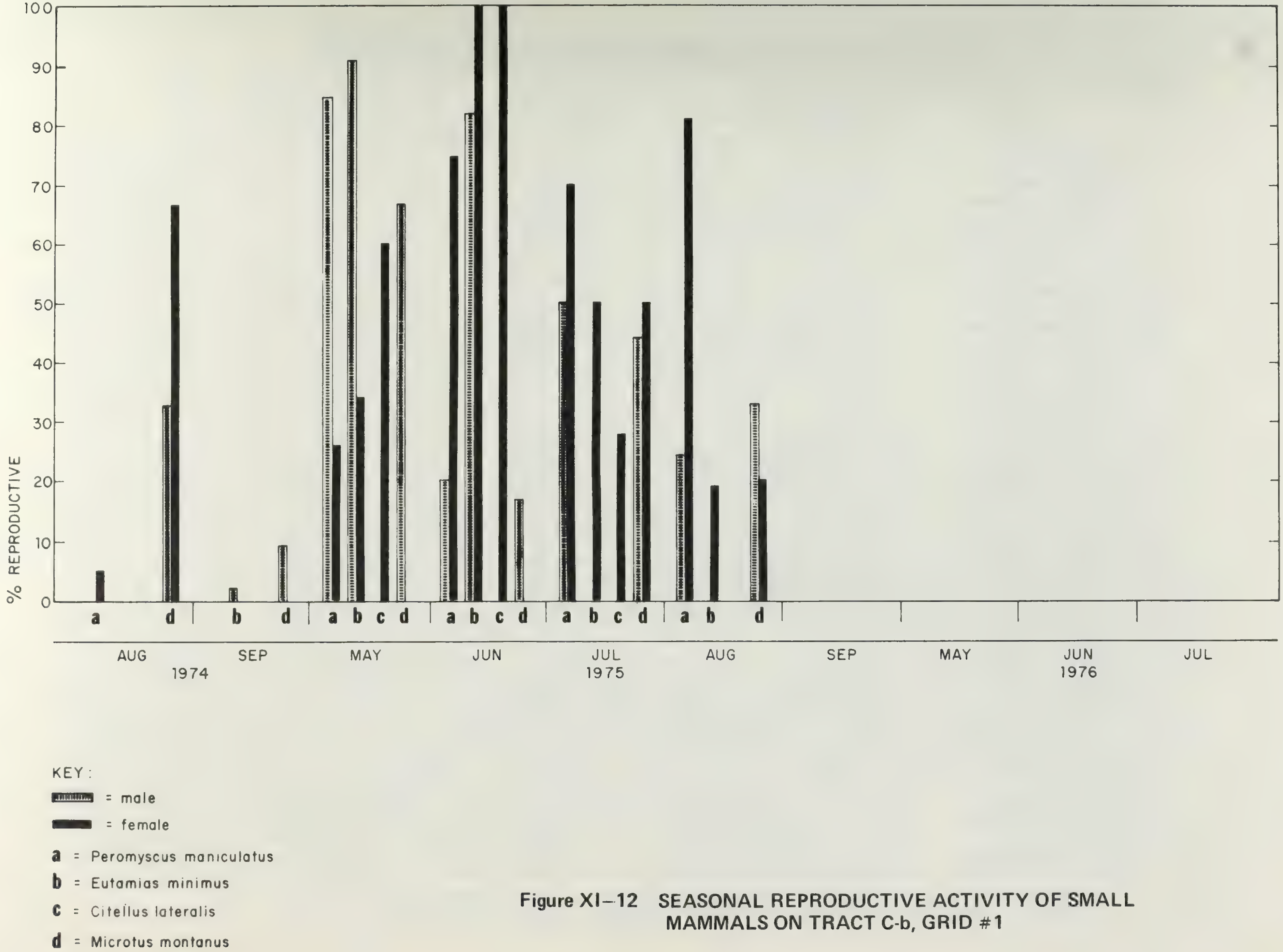


Figure XI–12 SEASONAL REPRODUCTIVE ACTIVITY OF SMALL MAMMALS ON TRACT C-b, GRID #1

for the year.

There is no apparent reason for the differences observed between female reproductive condition in August 1974 sampling and the August 1975 sampling. Differences in such factors as primary vegetation production, population densities, male-female ratios and temperature regimes may be important influences on the reproductive condition of deer mice. Preliminary evidence shows that the average embryo count for the deer mouse on the Tract is 5.0 (N = 12).

Female chipmunk's reproductive cycles began in May and increased to 100% by June. Ninety-one percent of the male population were in the reproductive state in May. The percentage then dropped and by September no males were in reproductive condition (Figure XI-12). The least chipmunk had an average of 5.6 (N = 6) embryos implanted.

-- Food Habits

The deer mouse is an omnivore that will eat plant material, seeds, miscellaneous arthropods and other invertebrate animals. Table XI-9 shows the relative frequency of diet items for the deer mouse. In the spring, vegetation is not as important a food item as are insects. As the season progresses, the relative frequency of plant material increases (19.2% in May to 47.2% in August). Insect food decreases over this period. The implication is that as primary vegetation production peaks in the summer, the importance of plant material in the deer mouse diet also increases.

A large proportion of the least chipmunk's diets are green plant material, which had a relative frequency in the diet of greater than 50% except in July (Table XI-9). During the Month of August 1975, after flowering had been completed for most plant species and seed set had been accomplished, seed items in chipmunk diet increased in relative frequency. Insects and other arthropods also made up a large proportion of the least chipmunk's diet. Arthropods were utilized in July when there is a peak in arthropod populations.

-- Habitat

Habitat utilization by the deer mouse is probably the most ubiquitous of any species on the Tract. This species is widespread throughout the chained pinyon-juniper rangeland and shows no particular preference for any one kind of microhabitat. It occurs in abundance along fallen trees, around shrubs, and in the grassy patches.

The least chipmunk has been encountered in most habitats on the Tract. At the chained site, this species is abundant in and around shrubs and fallen trees. Where the chained rangeland borders on the pinyon-juniper woodland to the west, the least chipmunk is sympatric with the Colorado chipmunk. This habitat is characterized by xeric slopes and rimrock with a pinyon-juniper overstory and sparse understory.

Table XI–9 RELATIVE FREQUENCIES OF SMALL MAMMAL DIET ITEMS FOR MAY, JUNE, JULY AND AUGUST, 1975

Species / Diet Item	May		June		July		August	
	Site 1*	Site **	Site 1	Site 2	Site 1	Site 2	Site 1	Site 2
Peromyscus maniculatus								
Vegetation	19.2%	22.2%	31.7%	21.2%	50.0%	55.7%	47.2%	39.4%
Arthropod	79.1%	75.9%	68.3%	78.8%	50.0%	40.5%	50.9%	60.6%
Seed	1.7%	1.9%	0	0	0	3.8%	1.9%	0
Stomachs Examined	6	4	3	4	1	2	3	4
Eutamias minimus								
Vegetation	50.7%	66.2%	67.9%	61.1%	30.9%	-	56.9%	63.4%
Arthropod	48.6%	33.8%	32.1%	38.9%	69.1%	-	33.9%	27.2%
Seed	0.7%	0	0	0	0	-	9.2%	9.4%
Stomachs Examined	3	2	1	1	2	-	7	5

* Grid 1 – Trapping site located in chained pinyon-juniper

** Grid 2 – Trapping site located in pinyon-juniper woodland

-- Grid #2 - Pinyon-Juniper Woodland Site

For the year from August 1974 through August 1975, a total of 1,154 individual small mammals have been captured over 2600 trap-nights. This represents an overall trapping success for the year of 44.3%. In terms of population estimates, it is apparent that seasonal and annual fluctuations occur (Table XI-7). Population estimates for all species for the grid ranged from 24.3 animals in June 1975 to 72.6 animals in August 1975. Spring and summer lows are followed by late summer highs. Figure XI-13 shows the fluctuations in the total population for the year. Figure XI-14 shows relative seasonal activities of small mammals for Grid #2.

-- Density

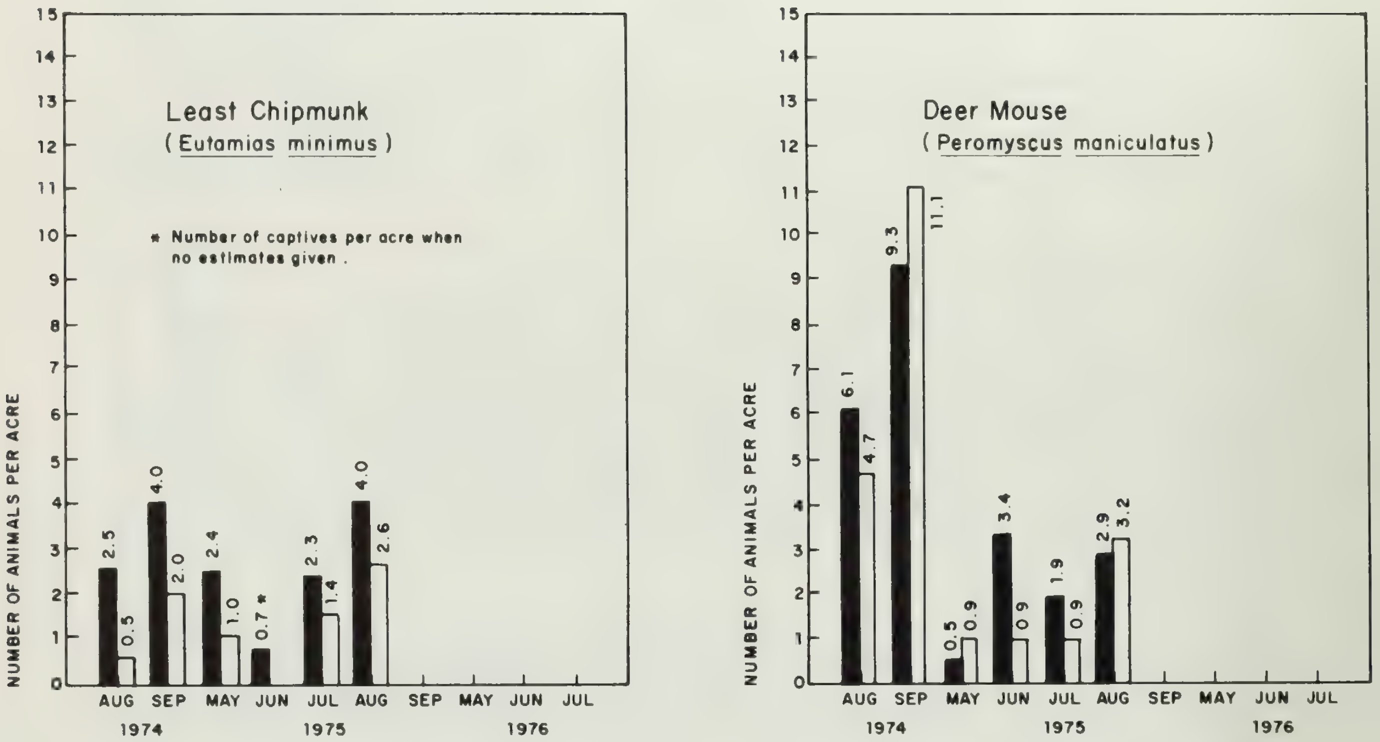
Fluctuations in density for the deer mouse at the pinyon-juniper site (Grid #2) were very similar to fluctuations at the chained site (Grid #1). Average densities were highest in September 1974 with 20.5 animals/hectare. This figure compares favorably with the 18.5 animals/hectare estimate at the chained site. After the winter the average density was 1.3 animals/hectare (May 1975). This figure increased to 6.5/hectare in August 1975, which was less than half the density of the previous August.

The least chipmunk is the second most abundant small mammal at the pinyon-juniper site. Its population estimates also fluctuate seasonally and yearly (Table XI-7). For example, August 1974 estimates for the trapping grid were 14.8 animals. The number increased to 23.7 in September and then declined to 9.4 animals in May 1975. The lowest numbers were observed in June 1975 (5.0 animals) and the highest in August 1975 (46.0 animals). A three-fold difference in chipmunk numbers is seen from August 1974 (14.8) to August 1975 (46.0), and suggests a successful 1975 reproductive effort. In terms of average number of animals/hectare over the first year of study, the range was 1.72 animals/hectare to 14.1 animals/hectare.

-- Recapture Success

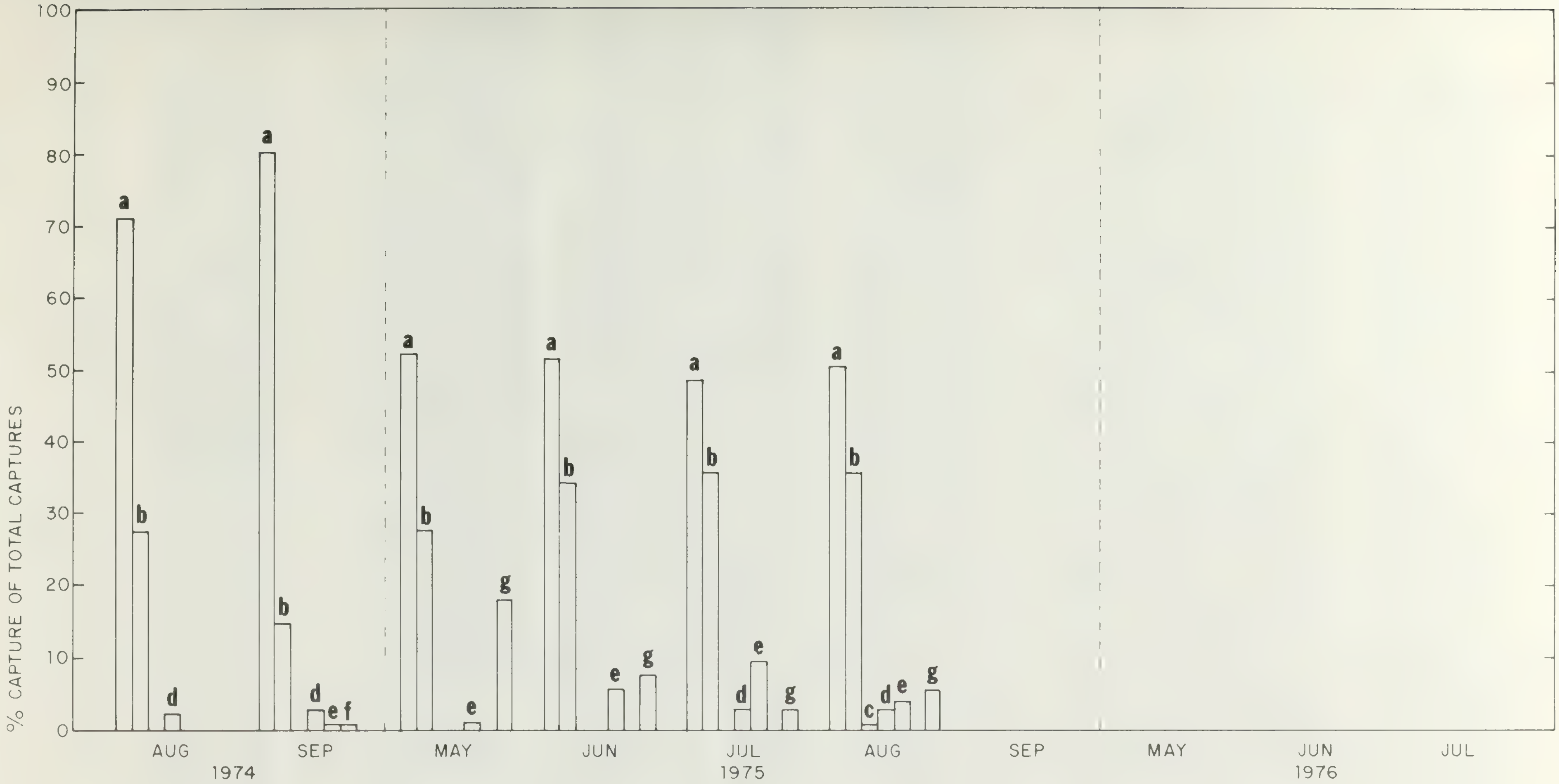
During August 1974 a total of 41 deer mice were marked at the pinyon-juniper grid. Eleven of these individuals were recaptured in September. Throughout the 1975 trapping season only four of the 41 individuals were recaptured, and by August 1975 none of the original 41 were encountered again. Sixty-three deer mice were marked in September 1974. Only one of these individuals was recaptured in 1975. These data indicate that of the 104 deer mice marked in 1974, five remained on the grid during spring and summer, and all had disappeared at the end of August 1975.

During May through July, twenty-two deer mice were marked. Their recapture success in August 1975 was 12.5%. Of 19 new animals marked in August 1974, 50% were recaptured in September. Fifty-one animals were



NOTE:
■ = Hayne population estimate
□ = EM-2 population estimate

Figure XI–13 SEASONAL DENSITY ESTIMATES FOR SMALL RODENTS ON TRACT C-b, GRID #2



KEY.

a = Peromyscus maniculatus
b = Eutamias minimus
c = Microtus montanus
d = Neotoma cinerea
e = Citellus lateralis
f = Perognathus apache
g = Eutamias quadrivittatus

Figure XI-14 RELATIVE SEASONAL ACTIVITY OF SMALL RODENTS ON TRACT C-b, GRID #2

marked during 1975. Density estimates at the end of August 1975 were about half the previous August estimates. Approximately 10% of the deer mice captured in 1975 were marked in 1974, which indicates high turn-over rates. The implication is that the deer mouse population is primarily an annual population with the majority of the mice being replaced by new individuals each year.

Ten individual least chipmunks were captured and marked in August 1974. The following month six were recaptured (60% success). During 1975 four were recaptured, and one animal was still present in September 1975. Of 28 individuals marked in September 1974, three were still present in August, 1975. During this month 12% of all previously marked individuals were still present on the grid. This is slightly higher than the deer mouse figure of 8.3%. Survival rate for both least chipmunk and deer mouse are more similar at Grid #2 than at Grid #1, and imply that environmental factors may apply equally to both species.

-- Biomass

September 1974 biomass estimates for the deer mouse are very similar to those reported for Grid #1. The total average biomass value was 471.5 gms/hectare. Total average biomass for May 1975 was 28.2 gms/hectare. This represents a 94% decrease in biomass over the winter, and is only one-third of the biomass estimate for the chained site for the same time period.

During September 1975, 29 deer mice were examined; their total average biomass was 68.4 gms/hectare. Only 14.5% of the original biomass present in the previous September.

The live weights for the chipmunks in September 1974 include both the least chipmunk and the Colorado chipmunk. These weights are reported in the section for Grid #1. An average of 7.0 chipmunks/hectare occurred on the pinyon-juniper site during this time. Total average chipmunk biomass was therefore 305.41 gms/hectare. Total mean biomass was 1.1 times that of biomass at Grid #1.

The May 1975 live weight determinations included 23 animals. Total mean biomass was 120.70 gms/hectare or only one-fourth of the chipmunk biomass at the chained study site. The difference results from a higher density of least chipmunks at the pinyon-juniper site during May 1975 since mean live weights are essentially the same. No biomass estimates were available for September 1975 since only one chipmunk was weighed.

-- Reproductive Activity

Figure XI-15 shows reproductive activity of small mammals on Grid #2. In August 1974, no male deer mouse reproductive activity was observed but 16% of the female population was reproductive. In May, at the start of the 1975 survey period, 85% of the males and 64% of the females were reproductive. This is similar to reproductive activity for the chained

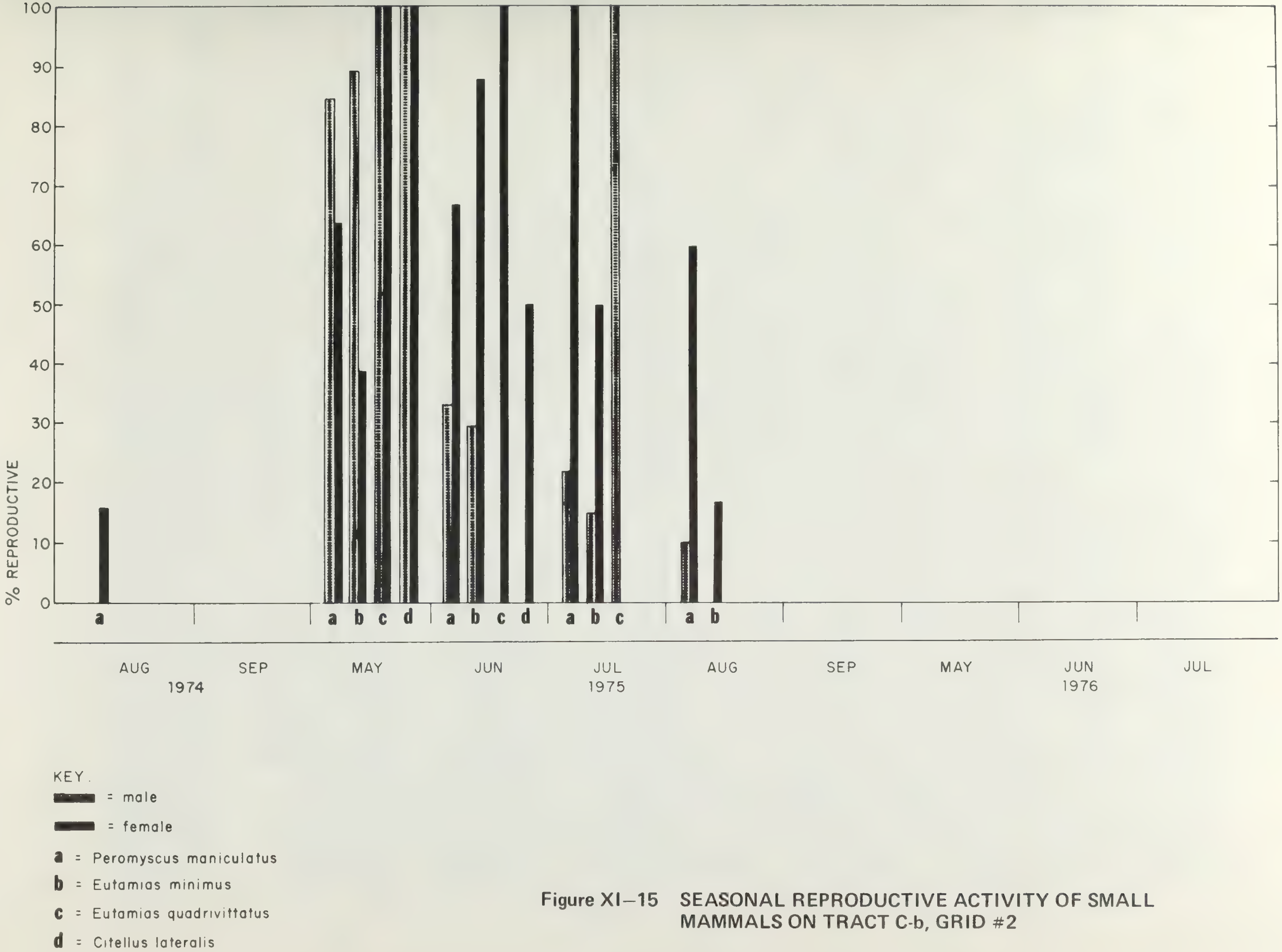


Figure XI–15 SEASONAL REPRODUCTIVE ACTIVITY OF SMALL MAMMALS ON TRACT C-b, GRID #2

site. Male activity decreased over the summer while female activity remained high (91% in July and 60% in August). In contrast to 1974, the indication is that the greater proportion of reproductive females were having two litters.

The reproductive cycle for both male and female chipmunks at this study site was similar to that at the chained site: males became reproductively active first and then gradually decreased in activity through the year; females peaked in June but were still active in August. There was no change in the proportion of reproductive females when comparing August 1974 to August 1975.

-- Food Habits

Insects formed a large proportion of the diet of the deer mouse in May and June. Plant material was apparently not a preferred item in May or June but increased in relative frequency in July. These data imply that the deer mouse may be shifting its preference for diet items as the season progresses.

A large proportion of the least chipmunk's diet, in terms of relative frequencies, is green plant material. Food habits at this study site are very similar to those at the chained site. Throughout 1975, plant material was encountered at greater than 50% frequencies in the stomachs of the least chipmunk. In August 1975 the frequency of seeds increased from 0% to 9.4%. The incidence of insects in the diet ranged between 27.2% and 38.9% which follows closely findings at Grid #1. The data suggest that as the winter approaches, seeds become more important to the least chipmunk.

-- Habitat

The habitat for the deer mouse at this study site is a pinyon-juniper woodland mixed with an understory of big sagebrush, serviceberry and mountain mahogany, among others. The lack of fallen trees and grasses may account for the slight decreases in density when compared to the chained site, since less habitat is available for utilization.

The pinyon-juniper woodland study site is characterized by an overstory of mature and sapling pinyon pines and junipers. Grasses are sparse and the soils are shallow. In terms of chipmunk habitat, where the woodland extends to the xeric slopes and rimrock, the Colorado chipmunk becomes more abundant and the least chipmunk less abundant.

-- Additional Species of Small Mammals

Several additional species of small mammals were found on the two intensive study grid sites. These include the montane vole (Microtus montanus) the Apache pocket mouse (Perognathus apache), the bushy-tailed woodrat (Neotoma cinerea), the golden-mantled ground squirrel (Spermophilus lateralis), and the Colorado chipmunk (Eutamias quadrivittatus). There are insufficient data to determine population estimates for these species.

The montane vole, found on the chained pinyon-juniper site, was captured with some regularity. Overall, the numbers of individuals captured in each trapping period was not sufficient to provide reliable estimates of population densities. The population estimates for the grid, however, were: 1.7 animals/1.5 animals (Hayne/EM-2) - August 1974: 13.0/0.6 - September 1974; 1.0/1.0 - May 1975; 6.7/6.3 - June 1975; 10.4/8.6 - July 1975, and 22.2/8.0 - August 1975.

Although montane voles were not captured in sufficient quantities on the two quantitative trapping grids to deserve special attention in discussuion of small mammal communities in these habitats, voles were present in substantial numbers in agricultural meadows near the Tract. Voles were frequently sighted in these meadows, and their runways are evident and indicative of large numbers. Their abundance in these meadows makes them an important food source for coyotes and raptors, as described in the section on predator-prey relationships.

A list of mammals on the Tract is shown in Table XI-10. This list was composed from the results of all the above-mentioned survey programs, as well as those mentioned in the sections on Big Game and Medium-sized Mammals.

2. Birds

To develop information on the kinds and abundances of birds utilizing Tract habitats during different seasons, a number of survey methods were employed to determine presence and numbers of songbirds, upland gamebirds, waterfowl and raptors. Songbird and mourning dove abundance in eight different habitats (Figure XI-1), were each determined by Emlen strip transect techniques. In this method an observer walks slowly along a standard 800-foot-wide by 2500-foot-long transect and records all individuals seen or heard, according to their perpendicular distances from the transect route. These distances are used to establish the observation zone beyond which a species' conspicuousness declines; the limits of this zone are species-specific, and are used to calculate actual abundance of each species within the sample transect area. The Emlen strip transect technique permits calculation of density, and is used to quantify numbers of individuals per unit area of a specific habitat type. When employed to obtain quantified baseline data which will form the norm for future comparisons, this transect technique is used within relatively homogenous habitats. Dominant bird species within each vegetative type were determined by ranking relative density of all species. During the initial year of field work replicate counts were not made along each transect during each period, therefore, the data are not amenable to statistical analysis of sample variance. Density variations between seasons, habitats and years can be tested by simple non-parametric analyses.

Species which prefer mixed or "edge" habitats, or species occupying very limited patches of specialized habitat such as small cattail marshes or the small stands of cottonwoods in Cottonwood Gulch, cannot be properly surveyed by transect techniques. Edge habitats and small but unusual habitat patches were inventoried by qualitative censuses, to achieve a complete inventory of

Table XI–10 MAMMALS FOUND ON AND AROUND TRACT C-b *

Scientific Name	Common Name
Canis latrans	Coyote
Citellus lateralis	Golden-mantled ground squirrel
Cittelus richardsonii	Richardson's ground squirrel
Erethizon dorsatum	Porcupine
Eutamias minimus	Least chipmunk
Eutamias quadrivittatus	Colorado chipmunk
Eutamias umbrinus	Uinta chipmunk
Lagurus crutatus	Sagebrush vole
Lepus townsendii	White-tailed jack rabbit
Lynx rufus	Bobcat
Mephitis mephitis	Striped skunk
Microtus montanus	Montane vole
Microtus pennsylvanicus	Meadow vole
Mustela erminea	Ermine
Mustela frenata	Long-tailed weasel
Neotoma cinerea	Bushy-tailed wood rat
Odocoileus hemionus	Mule deer
Ondatra zibethicus	Muskrat
Perognathus apache	Apache pocket mouse
Peromyscus maniculatus	Deer mouse
Peromyscus truei	Pinyon mouse
Procyon lotor	Raccoon
Sorex cinerea	Masked shrew
Sorex vagrans	Vagrant shrew

* Identified by sighting, live-trap, sign, etc.

Table XI–10 (Continued)

Scientific Name	Common Name
Sylvilagus audubonii	Desert cottontail
Thomonys talpoides	Northern pocket gopher
Zapus princeps	Western jumping mouse

bird species which utilize the full range of habitats on the Tract. Such qualitative observations thus satisfy an inventory role, whereas strip transect methods satisfy a baseline establishment role. Because of increased habitat coverage, more species are usually encountered in qualitative surveys than quantitative counts.

Raptorial birds were recorded by species, age class and location whenever hawks, eagles, vultures, owls or ravens were sighted. In addition, during the nesting period extensive searches were made of the entire Tract to locate raptor nest sites. Nests were watched for evidences of occupancy, their locations plotted on a map, and the habitat conditions surrounding the nest recorded. Pellets and casts were collected from nesting and roosting sites, and analysed to determine raptor use of prey species. During November 1974 and May 1975, a road transect was traversed at night to assess owl activity on the Tract

Waterfowl utilization of ponds close to the Tract was determined bimonthly throughout the first year of the program by recording the number of individuals present on the ponds, by species. Calculations of bird-use days were made.

During six periods of field inventory, a total of 119 species have been documented on and close to the Tract (Table XI-11). Thirty-six different species were noted in Tract habitats during mid-winter. A minimum of 84 species nest in the general Tract vicinity.

a. Songbirds

The October 1974 sampling period occurred near the end of the fall migration for most songbirds. Some species of migrating birds such as the barn swallow, cliff swallow, house wren and western flycatcher were still present during the October sampling period. Other species generally considered as mid-to-late migrants (e.g., mourning dove, mountain bluebird and red-winged blackbird) were also present.

By late November, many migratory species had left the Tract region and some winter residents had begun to appear. Many of these fed and rested in loosely organized flocks which moved along topographic features such as drainages and ridges. The species comprising these flocks tend to exhibit a much less specific attachment to a particular habitat than they do during the breeding season. Because of this flocking behavior, large areas of suitable habitat were devoid of birds during fall and winter while small areas showed very high bird density. Species composition during migration is dynamic within a region, and a wave of any one migrant species can quickly be replaced by a wave of another species. In addition, densities vary markedly from day to day. The fall censuses exemplified the uneven pattern of bird distribution typical of temperate regions during this season. Because of this characteristic dynamism, data collected during migration periods on avian community composition, species abundance and species distribution generally do not lend themselves to meaningful quantitative comparisons. Rather,

Table XI–11 SPECIES OF BIRDS OBSERVED ON TRACT C-b DURING THE FIRST YEAR'S INVESTIGATIONS

ORDER FAMILY Species	Common Name	Season of Observation			
		Fall	Winter	Spring	Summer
ANSERIFORMES (Screamers, Swans, Geese and Ducks)					
ANATIDAE (Swans, Geese and Ducks)					
Anas platyrhynchos	Mallard	x	x	x	x
Anas strepera	Gadwall	x	x		
Anas crecca	Green-winged teal	x	x	x	x
Anas discors	Blue-winged teal	x			x
Anas americana	American widgeon	x	x	x	
Anas clypeata	Northern shoveler	x			
Anas cyanoptera	Cinnamon teal			x	x
Aix sponsa	Wood duck			x	
Bucephala clangula	Common goldeneye		x	x	
Bucephala islandica	Barrow's goldeneye		x		
Bucephala albeola	Bufflehead		x		
Mergus serrator	Red-breasted merganser		x		
FALCONIFORMES (Vultures, Hawks and Falcons)					
CATHARTIDAE (Vultures)					
Cathartes aura	Turkey vulture			x	x

Table XI–11 (Continued)

ORDER FAMILY Species	Common Name	Season of Observation Fall	 Winter	 Spring	 Summer
FALCONIFORMES (Cont.)					
ACCIPITRIDAE (Kites, Hawks and Eagles)					
Accipiter gentilis	Goshawk				x
Accipiter cooperii	Cooper's hawk				x
Circus cyaneus	Marsh hawk	x			
Buteo lagopus	Rough-legged hawk	x	x	x	
Buteo jamaicensis	Red-tailed hawk	x		x	x
Aquila chrysaetos	Golden eagle	x	x	x	x
Haliaeetus leucocephalus	Bald eagle			x	
FALCONIDAE (Caracaras and Falcons)					
Falco sparverius	American kestrel	x	x	x	x
Falco mexicanus	Prairie falcon	x		x	
GRUIFORMES (Cranes and Allies)					
RALLIDAE (Rails, Gallinules and Coots)					
Fulica americana	American coot	x			x
Grus canadensis	Greater sandhill crane	x			
CHARADRIFORMES (Shorebirds, Gulls, Auks and Allies)					
CHARADRIIDAE (Plovers, Turnstones and Surfbirds)					
Charadrius vociferus	Killdeer			x	x

Table XI–11 (Continued)

ORDER FAMILY Species	Common Name	Season of Observation Fall	 Winter	 Spring	 Summer
CHARADRIFORMES (Cont.)					
SCOLOPACIDAE					
Tringa solitaria	Solitary sandpiper				x
Capella gallinago	Common snipe		x	x	x
PHALAROPODIDAE (Phalaropes)					
Steganopus tricolor	Wilson's phalarope				x
COLUMBIFORMES (Sand-grouse, Pigeons and Doves)					
COLUMBIDAE (Pigeons and Doves)					
Zenaidura macroura	Mourning dove	x		x	x
STRIGIFORMES (Owls)					
TYTONIDAE (Barn Owls)					
Tyto alba	Barn owl	x			
STRIGIDAE (Typical owls)					
Otus asio	Screech owl	x			x
Bubo virginianus	Great horned owl	x	x	x	x
Asio otus	Long-eared owl	x			
Nyctea scandiaca	Snowy owl		x		
Aegolius acadicus	Saw-whet owl				x

Table XI–11 (Continued)

ORDER FAMILY Species	Common Name	Season of Observation Fall	 Winter	 Spring	 Summer
CAPRIMULGIFORMES (Goatsuckers, Oilbirds and Allies)					
CAPRIMULGIDAE (Goatsuckers)					
Phalaenoptilus nuttalli	Poor-will				x
Chordeiles minor	Common nighthawk				x
APODIFORMES (Swifts and Hummingbirds)					
APODIDAE (Swifts)					
Aeronautes saxatalis	White-throated swift				x
TROCHILIDAE (Hummingbirds)					
Selasphorus platycercus	Broad-tailed hummingbird				x
CORACIIFORMES (Kingfishers, Motmots, Rollers, Bee-eaters and Hornbills)					
ALCEDINIDAE (Kingfishers)					
Megaceryle alcyon	Belted kingfisher			x	
PICIFORMES (Woodpeckers, Jacamars, Toucans and Barbets)					
PICIDAE (Woodpeckers and Wrynecks)					
Colaptes auratus	Common flicker	x	x	x	x
Sphyrapicus thyroideus	Williamson's sapsucker				x
Dendrocopos villosus	Hairy woodpecker	x			
Dendrocopos pubescens	Downy woodpecker		x		x

Table XI–11 (Continued)

ORDER FAMILY Species	Common Name	Season of Observation			
		Fall	Winter	Spring	Summer
PASSERIFORMES (Perching birds)					
TYRANNIDAE (Tyrant flycatchers)					
Myiarchus cinerascens	Ash-throated flycatcher				x
Sayornis saya	Say's phoebe			x	x
Epidonax wrightii	Gray flycatcher				x
Epidonax difficilis	Western flycatcher	x			
Contopus sordidulus	Western wood pewee			x	x
Nuttallornis borealis	Olive-sided flycatcher				x
ALAUDIDAE (Larks)					
Alauda arvensis	Horned lark	x	x		x
HIRUNDINIDAE (Swallows)					
Hirundo rustica	Barn swallow	x			x
Petrochelidon pyrrhonota	Cliff swallow	x			x
Tachycineta thalassina	Violet-green swallow				x
Iridoprocne bicolor	Tree swallow				x
Stelgidopteryx ruficollis	Rough-winged swallow				x

Table XI–11 (Continued)

ORDER FAMILY Species	Common Name	Season of Observation Fall	 Winter	 Spring	 Summer
PASSERIFORMES (Cont.)					
CORVIDAE (Jays, Magpies and Crows)					
Cyanocitta stelleri	Steller's jay	x	x		
Aphelocoma coerulescens	Scrub jay	x		x	x
Gymnorhinus cyanocephalus	Pinyon jay	x	x	x	x
Pica pica	Black-billed magpie	x	x	x	x
Nucifraga columbiana	Clark's nutcracker	x	x	x	x
Corvus corax	Common raven	x	x	x	x
Corvus brachyrhynchos	Common crow	x			
PARIDAE (Chickadees, Titmice, Verdins and Bushtits)					
Parus atricapillus	Black-capped chickadee	x	x		
Parus gambeli	Mountain chickadee	x	x	x	x
Parus inornatus	Plain titmouse			x	
SITTIDAE (Nuthatches)					
Sitta carolinensis	White-breasted nuthatch	x	x		x
Sitta canadensis	Red-breasted nuthatch	x	x		

Table XI–11 (Continued)

ORDER FAMILY Species	Common Name	Season of Observation Fall	 Winter	 Spring	 Summer
PASSERIFORMES (Cont.)					
TROGLODYTIDAE (Wrens)					
Troglodytes aedon	House wren	x			x
Salpinctes obsoletus	Rockwren	x			x
Catherpes mexicanus	Canyon wren	x		x	
MIMIDAE (Mockingbirds and Thrashers)					
Sporeoscoptes montanus	Sage thrasher	x			x
TURDIDAE (Thrushes, Solitaires and Bluebirds)					
Turdus migratorius	Robin	x	x	x	x
Myadestes townsendii	Townsend's solitaire	x	x		x
Hylocichla guttata	Hermit thrush				x
Sialia currucoides	Mountain bluebird	x		x	x
SYLVIIDAE (Gnatcatchers and Kinglets)					
Polioptila caerulea	Blue-gray gnatcatcher				x
Regulus calendula	Ruby-crowned kinglet	x			

Table XI–11 (Continued)

ORDER FAMILY Species	Common Name	Season of Observation Fall	Winter	Spring	Summer
PASSERIFORMES (Cont.)					
LANIIDAE (Shrikes)					
Lanius excubitor	Northern shrike	x	x	x	
Lanius ludovicianus	Loggerhead shrike			x	
STURNIDAE (Starlings)					
Sturnus vulgaris	Starling	x		x	x
VIREONIDAE (Vireos)					
Vireo solitarius	Solitary vireo				x
Vireo olivaceus	Red-eyed vireo				x
Vireo gilvus	Warbling vireo				x
PARULIDAE (Wood warblers)					
Mniotilta varia	Black-and-white warbler				x
Vermivora ruficapilla	Orange-crowned warbler				x
Vermivora virginiae	Virginia's warbler				x
Dendroica petechia	Yellow warbler				x
Dendroica coronata	Yellow-rumped warbler	x			x
Dendroica nigrescens	Black-throated gray warbler				x
Geothlypis trichas	Common yellowthroat				x
Oporornis tolmiei	MacGillvray's warbler				x
Wilsonia pusilla	Wilson's warbler				x

Table XI–11 (Continued)

ORDER FAMILY Species	Common Name	Season of Observation Fall	 Winter	 Spring	 Summer
PASSERIFORMES (Cont.)					
ICTERIDAE (Blackbirds and Orioles)					
Dolichonyx oryzivorus	Bobolink				x
Sturnella neglecta	Western meadowlark	x		x	x
Agelaius phoeniceus	Red-winged blackbird	x		x	x
Euphagus cyanocephalus	Brewer's blackbird	x			x
Molothrus ater	Brown-headed cowbird				x
THRAUPIDAE (Tanagers)					
Piranga ludoviciana	Western tanager				x
FRINGILLIDAE (Grosbeaks, Finches, Sparrows, and Buntings)					
Pheucticus melanocephalus	Black-headed grosbeak				x
Carpodacus mexicanus	House finch	x			x
Leucosticte tephrocotis	Gray-crowned rosyfinch		x		
Leucosticte atrata	Black rosy finch		x		
Leucosticte austcalis	Brown-capped rosy finch		x		
Spinus pinus	Pine siskin	x			x
Spinus tristis	American goldfinch	x			
Chlorura chlorura	Green-tailed towhee				x

Table XI–11 (Continued)

ORDER FAMILY Species	Common Name	Season of Observation			
		Fall	Winter	Spring	Summer
PASSERIFORMES (Cont.)					
FRINGILLIDAE (Cont.)					
Pipilo erythrophthalmus	Rufous-sided towhee				x
Passerculus sandwichensis	Savannah sparrow	x			
Calamospiza melanocorys	Lark bunting				x
Pooecetes gramineus	Vesper sparrow	x			x
Amphispiza belli	Sage sparrow				x
Junco hyemalo	Dark-eyed junco		x	x	
Junco caniceps	Gray-headed junco	x	x	x	x
Spizella arborea	Tree sparrow	x	x	x	
Spizella passerina	Chipping sparrow				x
Spizella breweri	Brewer's sparrow				x
Zonotrichia leucophrys	White-crowned swallow	x			x
Melospiza melodia	Song sparrow	x	x	x	x

censuses made during migration periods serve as an inventory basis to establish the full complement of bird species' utilization of an area through an annual cycle. In this regard, migrating species are opportunistic in use of specific localities. Obtaining a complete inventory of such species requires several years. Consequently, data collected during periods of migration are not suitable for quantitative baseline definition.

In the fall, the most abundant species within the pinyon-juniper and sagebrush habitat were the mountain bluebird, Townsend's solitaire and yellow-rumped warbler. Black-capped chickadees, mountain chickadees and ruby-crowned kinglets dominated the mountain shrub community. The riparian area was inhabitated principally by mourning doves, white-crowned sparrows and song sparrows. By late November most migrants had left the area, leaving only those species which winter on the Tract. The pinyon-juniper and bottomland sagebrush habitats tend to be utilized in the late fall by the white-breasted nuthatch, American robin, Townsend's solitaire and northern shrike. Birds typically found in the riparian meadow habitat during late fall included the American robin, starling, white crowned sparrow and song sparrow. The pinyon-jay, mountain chickadee, red-breasted nuthatch and Townsend's solitaire were characteristic of the pinyon-juniper woodland in late fall. Piceance Creek valley was dominated by starlings, song sparrows and American robins. Mountain chickadees, dark-eyed juncos and gray-headed juncos were distributed throughout the mountain brush community. The American robin northern shrike and tree sparrow were found in the mixed rabbitbrush-sagebrush areas.

Virtually all migrant species observed during the fall inventory period had left the Tract by January. Some individuals of certain migratory species such as the horned lark, American robin and tree sparrow were most likely individuals that moved into the area subsequent to nesting in more northerly localities.

The winter survey also showed the restricted pattern of habitat utilization typical of bird species in temperate regions during mid-winter. Because many species flock together during winter, it is difficult to determine accurately the relative abundance of different species.

Flocking tendencies in some species or the tendency of other species to remain as solitary individuals (and hence to go undetected), influence which species are recorded and counted. Density of species contributing high percentages may thus be overestimated, while abundance of species contributing low percentages may be underestimated.

By the March sampling period, many winter residents of the

Piceance Creek basin had commenced their northward migration. By April, many summer residents expected to nest in the vicinity were present in small numbers. These included the turkey vulture, killdeer, Say's phoebe, western wood pewee, mountain bluebird, red-winged blackbird, dark-eyed junco and gray-headed junco. The species encountered on the Tract during the early spring compared closely with the species expected, based on published information.

Twenty species of birds were observed on the Tract during the winter months that had not been seen at other times of the year. The six most abundant of these were the horned lark, American robin, gray-crowned rosy finch, black rosy finch, black-capped rosy finch and the tree sparrow. During the late winter, the red-winged blackbird was the most abundant bird in the meadows along Piceance Creek. Other birds included the starling, common raven and scrub jay. In West Fork Stewart Gulch, the Townsend's solitaire, black-billed magpie, song sparrow and mountain chickadee were present in relatively low numbers. In the pinyon-juniper woodland, the black-billed magpie and Townsend's solitaire were observed. Only 27 species were recorded during the qualitative counts made in late winter. Specific utilization of habitat by different species had become apparent by the time of census counts in the spring. By this time, many species of birds which nest in Tract habitats were present and males of some species were defending fixed territories. Certain migrants were still present during late May.

Between late May and mid-July 1975, a total of 84 bird species were recorded on and near the Tract (Table XI-12). Table XI-13 summarizes relative density values for principal species in four major Tract habitats, as calculated from results of transect censuses performed during January and July, two periods when species composition should be relatively stable. It is clear from these summaries that the Tract's avian communities change markedly from winter to summer. During winter, habitats in the Tract vicinity tend to support fewer species; most breeding species leave the Piceance Creek basin to winter at locations farther south. In woodland and shrub habitats, 80% to 89% of the breeding species did not remain through the winter. In meadow habitat along Piceance Creek, 68% of nesting species were migratory. Wiens (1975 Proceedings of the Symposium of Management of Forest and Range Habitats for Nongame Birds, p. 146-182) indicated that a high migratory propensity is typical of shrub-steppe avifaunas, and believed that the available supply of winter food (principally seeds) is lower in shrub communities than in grassland communities, thus accounting for a fall vacating of shrub habitats by breeding bird species.

Except for the chained pinyon-juniper habitat, each principal habitat contained five nesting species which achieved a relative abundance of about 10% or greater. The data demonstrate that chaining dramatically altered the species composition from that of the original woodland. Table XI-13, which tallies community characteristics of the chained and

Table XI–12 CHARACTERISTICS OF WINTERING AND BREEDING AVIFAUNA IN FOUR PRINCIPAL HABITATS IN TRACT C-b STUDY AREA

Species	Winter % Relative Density	Summer % Relative Density
PINYON-JUNIPER HABITAT		
Pinyon jay	12.3	
Mountain chickadee	30.4	7.3
Red-breasted nuthatch	41.4	
Chipping sparrow		31.5
Blue-gray gnatcatcher		9.7
House finch		9.7
Mourning dove		19.2
Solitary vireo		9.7
Number species recorded	6	10
Total density (no./km^2)	842	847
Dominance index	71.8	50.7
% of breeding species which are migratory	–	80.0
CHAINED PINYON-JUNIPER HABITAT		
House wren		54.2
Vesper sparrow		13.8
Brewer's sparrow		17.1
Number species recorded	0	7
Total density (no./km^2)	0	592
Dominance index	0	71.3
% of breeding species which are migratory	–	85.7
VALLEY SAGEBRUSH HABITAT		
American robin	28.9	
Tree sparrow	65.4	
Blue-gray gnatcatcher		19.7
Yellow-rumped warbler		13.0
Green-tailed towhee		13.3
Brewer's sparrow		29.2
Black-throated gray warbler*		23.5
Number species recorded	3	9
Total density (no./km^2)	266	315
Dominance index	94.3	52.7
% of breeding species which are migratory	–	88.9
RIPARIAN MEADOW HABITAT		
Wilson snipe	13.1	
Horned lark	49.9	
American robin	11.4	
Tree sparrow	15.3	
Red-winged blackbird		30.2
Song sparrow		10.7
Chipping sparrow		13.0
Say's phoebe		13.0
Yellowthroat		17.9
Number species recorded	7	9
Total density (no./km^2)	1883	476
Dominance index	65.2	48.1
% of breeding species which are migratory	–	66.7

*Species utilizing pinyon and juniper trees which were scattered within the valley sagebrush community.

Table XI-13 SPECIES NUMBERS, DENSITIES, AND DOMINANCE INDICES FOR AVIAN COMMUNITIES IN EIGHT HABITATS DURING 1974 and 1975 SAMPLING PERIOD

Habitat	Sampling Period					
	Oct.	Nov.	Jan.	Mar.	May	July
Canyon Slope of Sparse P-J, sage						
Number of species	1	–	5	–	6	–
Density	5	–	1081	–	285	–
Dominance index	100.0	–	90.5	–	51.2	–
Riparian Meadow						
Number of species	12	5	7	4	19	9
Density	1935	1307	1883	–	922	476
Dominance index	63.0	68.3	65.2	91.0	51.1	48.1
Bottomland Sagebrush						
Number of species	7	2	3	4	9	9
Density	226	15	266	–	699	315
Dominance index	68.2	100.0	94.3	60.0	58.0	52.7
Pinyon-Juniper						
Number of species	4	2	6	2	13	10
Density	94	25	842	–	902	847
Dominance index	89.4	100.0	71.8	100.0	36.0	50.7
Mixed Pinyon-juniper/sage/shrubs						
Number of species	2	–	4	–	10	–
Density	25	–	789	–	541	–
Dominance index	100.0	–	89.6	–	61.2	–
Chained Pinyon-juniper						
Number of species	4	2	0	0	10	7
Density	184	10	0	0	545	592
Dominance index	78.2	100.0	0	0	61.5	85.7
Upland Sagebrush						
Number of species	0	–	0	–	10	–
Density	0	–	0	–	887	–
Dominance index	0	–	0	–	69.1	–
Mountain Shrub						
Number of species	3	–	7	–	5	–
Density	249	–	1345	–	288	–
Dominance index	83.5	–	48.8	–	50.1	–

– indicates no census was performed during this sampling period.

unchained pinyon-juniper habitat for six sampling periods, shows further disparities between these habitats. Absence or sporadic occurrence of birds in the chained areas during winter probably is a consequence of strong winds which sweep the open areas, coupled with drifting snow, poor food availability and poor cover.

The dominance index, which summarizes relative densities for the two species achieving greatest density, indicates that most avian communities on the Tract are dominated by few species. The breeding assemblages of birds in Tract habitats are simple in structure. The summary values in the two tables also demonstrate substantial seasonal variations in density for most habitats. It is anticipated that such density variations are characteristic of the surveyed habitats. Based on recent literature on seasonal and annual variations in birds, it is expected that marked year-to-year variations in breeding densities will occur. It is expected, however, that the species composition of the breeding avifaunas will remain relatively stable from year to year in the absence of major disturbances.

b. Upland Game Birds

The only upland game bird encountered in the study area to date is the mourning dove. It appears that there is little satisfactory habitat for sage grouse on the Tract, and discovery of leks or nesting concentrations on the Tract is not anticipated. Blue grouse habitat appears restricted to points southeast and south of the Tract. No blue grouse have been seen to date on the Tract.

Mourning doves apparently concentrate in meadows along Piceance Creek during fall. Most doves had left the Tract by the time of the late fall-early winter census. Mourning doves reappeared by early April, when they were recorded in small numbers along Piceance Creek. Habitat in the Tract vicinity supports many nesting pairs during the breeding season. During the 1975 nesting period, doves were recorded in every habitat on the Tract, and were observed in four of the eight Emlen transect censuses.

c. Waterfowl

During the fall, the waterfowl in the impoundments along Piceance Creek included mallards, green-winged teal and blue-winged teal. During this period, these birds were subject to the activities of hunting season. Mallards and green-winged teal comprised the largest portion of the waterfowl in November. During winter, mallards and green-winged teal were the numerically dominant waterfowl, totalling 70% of all waterfowl present. The American wigeon, common goldeneye, and bufflehead contributed an additional 24% to relative abundance. The gadwall, Barrow's goldeneye and red-breasted merganser contributed the remaining 6%.

Late winter waterfowl counts conducted in March 1975, indicated high usage of the area by six waterfowl species. The mallard and green-winged teal dominated in total number. Pintails, American wigeon, cinnamon teal and common goldeneye were also present. Several species of waterfowl considered unusual in the region have been encountered near the Tract. These species include the Barrow's goldeneye, red-breasted merganser and Wilson's snipe. A single, male Barrow's goldeneye was identified in the P-L ranch pond during January 1975. The only other known documented record of this rare winter migrant in this region was by Good (1956, Dinosaur National Monument Notes), who saw a male goldeneye on the Green River northeast of Escalante Crossing. Four individuals, one male and three females, of the red-breasted merganser were observed on the P-L ranch pond in late January, 1975. Davis (1969, Birds in Western Colorado. Colorado Field Ornithologists, Boulder) classifies this species as an uncommon winter resident on open rivers. This species has been reported as a frequent visitor to the Green River in northeastern Utah and northwestern Colorado during migration in early May and late September. The Wilson's snipe has been observed repeatedly in the Tract vicinity and undoubtedly nests in the Piceance Creek basin. Previously, its known nesting range on the Western Slope included Routt, Moffat and Gunnison counties.

The P-L ranch pond was the only site of significant use by nesting waterfowl from May through July, 1975. Nine species were recorded at the impoundments near Piceance Creek. Mallards, green-winged teal and cinnamon teal were the dominant breeding species.

d. Raptors

Diurnal raptorial birds observed on the Tract during the October-November 1974 sampling periods included the red-tailed hawk, rough-legged hawk, golden eagle, marsh hawk and American kestrel. The barn-owl, screech owl, great horned owl and long eared owl were the nocturnal species observed during fall. The most abundant of the raptors were the golden eagle and marsh hawk.

During the winter, the species of raptors identified were rough-legged hawk, golden eagle, American kestrel, great horned owl and the snowy owl. The rough-legged hawk was by far the most frequently observed species, constituting about 75% of all sightings. Rough-legged hawks began appearing in the area during late November and were abundant in the Piceance Creek basin by mid-January. In March 1975, nine species of raptors were observed on the Tract. The most frequently observed species (about 62%) during the late winter was the common raven. The red-tailed hawk was also frequently observed. The rough-legged hawk, a species which was seen commonly during mid-winter, was observed on only two occasions during March and not at all during April. This species nests in the arctic, and its northward migra-

tion had commenced prior to mid-March. Golden eagles were seen on 12 occasions in April. One pair of golden eagles was observed carrying pine boughs to a nest, while another pair was observed killing a young mule deer. Examination of the deer indicated that it was in poor condition and apparently suffering from malnutrition. Three adult bald eagles were observed in the study area during this period. Like the rough-legged hawk, the bald eagle is a winter resident of the Piceance Creek basin and by April no bald eagles were present. The great horned owl was the only nocturnal species encountered during these late winter field trips. The northern shrike and loggerhead shrike were other raptor-like species present.

From May through July 1975, eight species of raptors were observed. The great horned owl was the most frequently encountered species (40%). Other species included the red-tailed hawk, the turkey vulture, American kestrel, goshawk and Cooper's hawk. A saw-whet owl observation was a previously unrecorded raptor on the Tract.

The barn owl is an unusual visitor to this portion of western Colorado. A single individual was observed perched on a fence post near the Tract on November, 1974. The distribution of home dwellings along Piceance Creek and the barn owl's preference for such habitations may account in part for its presence in this area. Few records of this owl exist for western Colorado. Similarly, only two records of snowy owls have been noted in the literature for northwestern Colorado. The presence of this species in southern temperate regions coincides with cyclic population patterns exhibited on its arctic breeding area. Peak owl populations coupled with dramatic declines in prey populations produce periodic winter "invasions" of many owls into the United States.

The prairie falcon, a species designated as "threatened" by the U.S. Fish and Wildlife Service, was identified on the Tract in February and September 1975. Although considered to be a rare resident in northwestern Colorado, prairie falcons apparently nest in many locations in the Piceance Creek basin. No evidence of nesting was found on or close to the Tract.

Excluding the two shrikes, 17 species of raptors were observed during the first year of field investigations, as indicated in Table XI-14. Nests of three different species were located, and it is probable that as many as 12 species nest in the general vicinity of the Tract. Field observations made between March and July, 1975 indicated that raptor activity on the Tract was low during the nesting period. The paucity of observations during the summer census periods is indicative of a small breeding population. This contrasts with the importance of the area to wintering raptors.

Table XI–14 RAPTORS NOTED ON OR CLOSE TO TRACT C-b DURING THE 1974-75 STUDY PERIOD

Species	Anticipated Status	Nest Sites Discovered
Turkey vulture	Summer resident	
Goshawk	Undetermined	
Cooper's hawk	Summer resident	
Marsh hawk	Permanent resident	
Rough-legged hawk	Winter resident	
Red-tailed hawk	Permanent resident	x
Golden eagle	Permanent resident	x
Bold eagle	Winter resident	
American kestrel	Permanent resident	
Prairie falcon	Permanent resident	
Barn owl	Permanent resident	
Screech owl	Permanent resident	
Great horned owl	Permanent resident	
Long-eared owl	Permanent resident	
Snowy owl	Winter resident	
Saw-whet owl	Permanent resident	
Raven	Permanent resident	x

3. Fish

Aquatic sampling stations are located on the three principal flowing streams near the Tract (Piceance Creek, Willow Creek and Stewart Creek) and at major identified springs and seeps within a mile of the Tract. In addition, there are two stations located on the White River. The sampling stations in the vicinity of the Tract are shown in Figure XI-16.

Monthly collections were begun in August 1974. Sampling was changed to a bimonthly program in January, 1975. The location and a description of each sampling station is given below.

Station P-C. Piceance Creek, just above the confluence of Piceance and Cow Creek. Substrate consists of mud, gravel and rubble. Several beaver dams exist in this area forming small pools in the creek. The station is located approximately 10 miles upstream from the Tract boundary. Trees and shrubs shade the stream at this station. This station is not a regular sampling station, but is used occasionally to study upstream conditions.

Station P-1. Piceance Creek, about one mile upstream from Stewart Gulch Road. Substrate consists of small rubble, mud and compacted clay. Grass and low shrubs line the banks.

Station P-2. Piceance Creek, at the Walter Oldland Ranch, below the confluence of Stewart Creek. Substrate consists of mud and compacted clay with some gravel and rubble. Grass and low shrubs line the banks. Corresponds roughly to Station 1 of May (1970, M.S., Thesis, Univ. Colo.) and Station PC-1 of Woodling and Kendall (1974 , Colo. Dept. of Pub. Health).

Station P-3. Piceance Creek, below Sorghum Gulch drainage. Substrate consists of small to medium rubble with some mud and clay. Some pools and riffles occur in this stretch and there is a small waterfall at the upper end of the station. Grass and low shrubs line the banks. Corresponds roughly to Station IV of Everhart and May (1973 , EPA Ecol. Res. Ser .)

Station P-4. Piceance Creek, below the Redd Ranch, near the meteorology station. Substrate consists of small rubble and mud. Grass and low shrubs line the bank. This station was moved and designated P-5A in November, 1974, because of the redundancy among similar stations P-3, P-4, and P-5. Station P-5A was added to provide a station on a stretch of stream below a waterfall, a habitat of narrow distribution not represented in the other Piceance Creek stations.

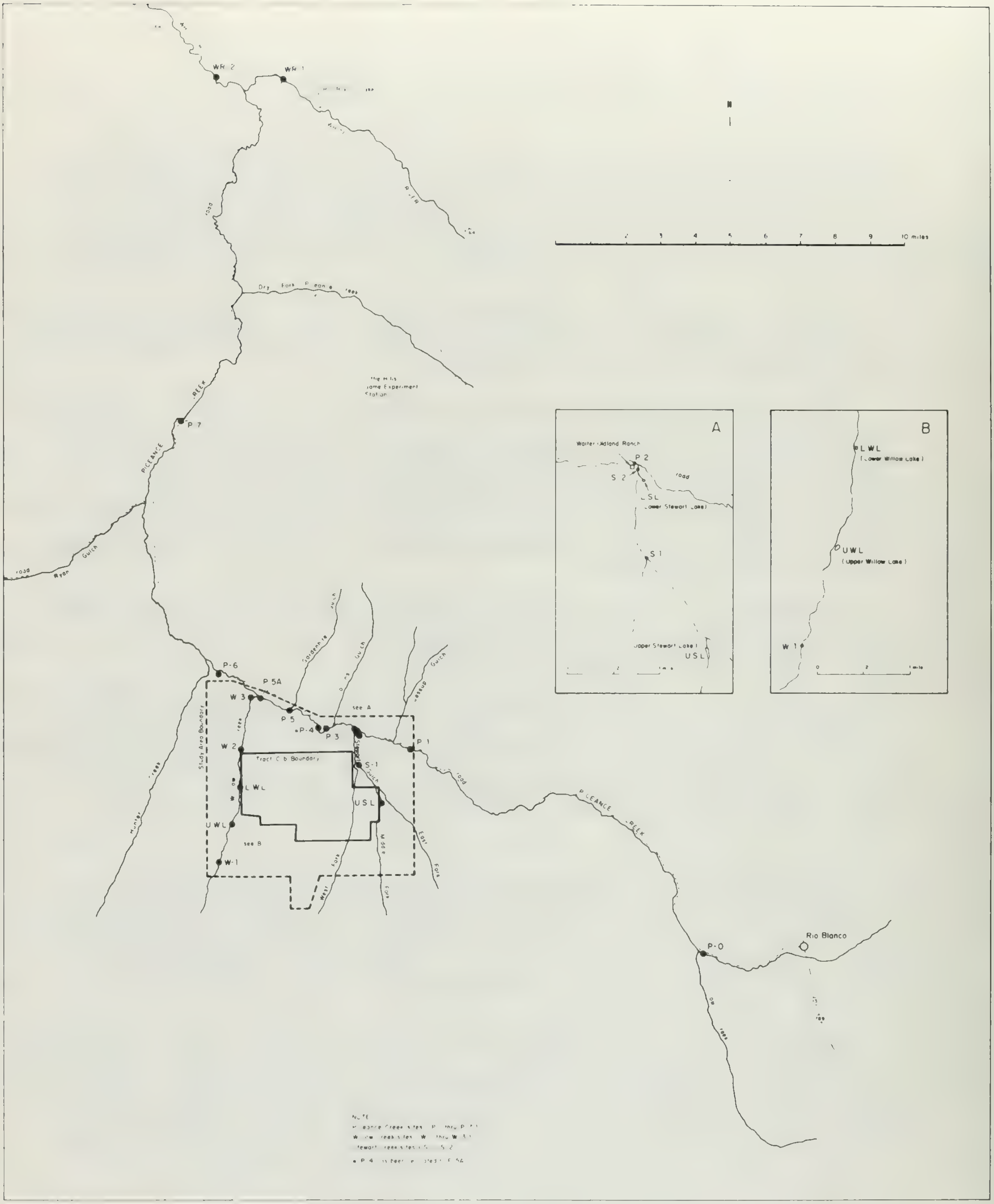


Figure XI-16 AQUATIC STUDY AREAS

Station P-5. Piceance Creek, approximately one mile above the confluence of Willow Creek and Piceance Creek. The substrate consists of small flat rubble, mud and compacted clay. Grass and low shrubs line the bank.

Station P-5A. Piceance Creek, approximately 300 yards above the confluence of Willow Creek and Piceance Creek, and downstream of the entrance road leading to Tract C-b. Substrate consists of flat rubble, gravel, mud and compacted clay. There is a man-made waterfall resulting from stream diversion approximately 12 feet high at the upper end of the station. There is a pool beneath logs at the base of the waterfall. Most of this station is shallow riffles below the falls. Grass and small shrubs line the bank. This station was established in November, 1974, when Station P-4 was discontinued.

Station P-6. Piceance Creek, approximately one mile below the confluence with Willow Creek, where the Hunter Creek Road crosses the stream, at USGS gauging station No. 09306061. Substrate consists of mud, compacted clay and some gravel. Grass and low shrubs line the bank. Corresponds roughly with Station PC-2 of Woodling and Kendall (1974, Colo. Dept. Pub. Health).

Station P-7. Piceance Creek, 7.8 miles downstream of Station P-6 along the Piceance Creek road (Section 21, R97W, T1S). Substrate consists of mud and compacted clay. Grass and low shrubs line the bank.

Station W-1. Willow Creek, approximately one mile upstream from the boundary of the Tract. Substrate consists of small, well-embedded rubble. The stream is spring-fed. Width is generally less than three feet and depth less than one foot. Grass and small shrubs line the bank. Watercress and aquatic plants grow in the stream in spring and summer.

Station W-2. Willow Creek, below the confluence of the drainage from Scandard Gulch, just outside the Tract boundary. The substrate consists of sandy silt and gravel. At this station the stream flows through a gulch cut about 25 feet deep into the meadow floor. The stream is generally less than three feet wide and one foot deep. A small waterfall about four feet high marks the upper end of the station. Grass and small shrubs line the banks. Aquatic plants grow in the stream in spring and summer.

Station W-3. Willow Creek, just above the confluence of Willow Creek and Piceance Creek. Substrate consists of gravel and sandy silt. The stream is generally less than three feet wide and one foot deep. Stream banks are lined with grass, shrubs, and willows. The stream becomes overgrown in summer in some places. Aquatic plants are much less frequent than at Stations W-1 and W-2. This station corresponds roughly to Station WC-1 of Woodling and Kendall (1974, Colo. Dept. Pub. Health).

Station U.W.L. Upper Willow Lake, approximately one mile downstream from Station W-1. Upper Willow Lake is a shallow spring-fed, man-made impoundment of about a half-acre. It has a black sand and muck bottom that is rich in organic detritus. A small weir at the opposite end from the spring source drains water into Willow Creek. The lake bank is flat and lined with grass and some shrubs. Aquatic vegetation is abundant in the lake.

Station L.W.L. Lower Willow Lake, approximately one mile north of Upper Willow Lake, is a small (0.1 acre) spring-fed pond about 10 feet deep. The spring source is in the bottom of the pond. It has a sand and muck bottom that is rich in organic detritus. Green algal growth is abundant on the lake bottom. The lake bank is flat and grass covered. The lake drains through a small channel into Willow Creek.

Station S-1. Stewart Creek, approximately one mile up Stewart Gulch from the Walter Oldland Ranch, where the road to West Fork Stewart Gulch crosses Stewart Creek at USGS gauging station No. 09306022. Substrate consists of small embedded rubble and some sandy silt. Stream banks are grass covered. Aquatic plants grow in the stream in spring and summer. Stream width is generally less than three feet and depth less than one foot. Stewart Creek is springfed. This station corresponds roughly with Station SC-1 of Woodling and Kendall (1974, Colo. Dept. Pub. Health).

Station S-2. Stewart Creek, just upstream from the confluence of Stewart Creek and Piceance Creek. Substrate consists of sandy silt and gravel. This portion of Stewart Creek flows through a grassy meadow. The channel draining lower Stewart Lake joins Stewart Creek at this station.

Station U.S.L. Upper Stewart Lake, in Middle Fork Stewart Gulch. The lake is a springfed, man-made impoundment of approximately two acres. The substrate is mud and silt, rich in organic detritus with abundant attached algal growth and aquatic plants. The lake bank is a grassy meadow.

Station L.S.L. Lower Stewart Lake, located about a quarter of a mile south of Piceance Creek road along the Stewart Gulch road near USGS gauging station No. 00306007 on the Walter Oldland Ranch. Lower Stewart Lake is a man-made impoundment about an acre in size. The substrate consists of small flat rubble and silt. The lake drains into a channel which flows into Stewart Creek. The lake has attached and floating algal growth as well as aquatic plants. Depth of the lake is about 10 feet.

Station WR-1. White River, approximately one mile above the confluence of Piceance Creek and the White River, where Piceance Creek road crosses the White River. Substrate consists of small to large

rubble, boulders, and sandy silt in the interstices. Grass and shrubs line the bank. This station corresponds roughly with Station VI of Everhart and May (1973 EPA, Ecol. Res. Ser.) and with Station 4 of Pennák (1974 , Thorne Ecol. Inst.)

Station WR-2. White River, approximately one mile below the confluence of Piceance Creek and the White River, where State Highway 64 crosses the White River. Substrate consists of small to large rubble and sandy silt. The river splits into several channels at times at this station. Grass and willows line the banks. This station corresponds roughly with Station 4 of Pettus (1974, Thorne Ecol. Inst.) and Station 3 of Pennak (1974, Thorne Ecol. Inst.)

Fish specimens are collected from the streams on a bi-monthly basis using a battery-operated backpack shocker. In the lakes and ponds, two 0.5 inch mesh nylon seines and backpack shocker are used to collect fish. Fish are marked and released in order to study migration patterns. Results of the marking and recapture program are presented in Table XI-15. In initial collections fish were marked by clipping one ventral fin. In May, 1975, a tagging method of marking was initiated. Tagging of fish allows for identification of individual fish in subsequent recoveries. The number of tagged fish recoveries has been insufficient to date to make an analysis of any migration that may occur.

As noted above, aquatic stations have been established on major springfed lakes on Stewart Creek and Willow Creek in the Tract area. Qualitative studies on the major flora and faunal groups of the springs and seeps are taking place, but results of these studies have not been completed and are not included.

Piceance Creek is generally characterized by a meandering stream channel, fluctuating flows, high levels of dissolved solids, high turbidity , silted rock and gravel substrates at certain times of the year, and infrequent pool and shelter areas for fish. At certain times rock and gravel substrates predominate with low silt levels. These factors make much of the habitat unsuitable for large game fish populations. However, game fish that occur in Piceance Creek appear healthy and in good condition. It is evident that the aquatic environment of Piceance Creek favors less desirable but more highly adaptable nongame species such as the mountain sucker and speckled dace. Willow Creek and Stewart Creek are small spring fed streams similar to Piceance Creek in terms of water quality and substrate. However, turbidity and siltation are not a problem in these streams as they are in Piceance Creek.

Three species of trout occur in the vicinity of the Tract; the Rainbow; Salmo gairdneri, the Brook; Salvelinus fontinalis, and the Brown; Salmo trutta. Other fish include the mountain sucker (Catostomus platyrhynchus), Speckled dace (Rhinichthys osculus), mottled sculpin

Table XI–15 NUMBERS OF FISH CAPTURED, MARKED AND RECAPTURED AT PICEANCE CREEK BASIN STATIONS FROM SEPTEMBER 1974 TO JULY 1975

Month and Station	Brook Trout			Rainbow Trout			Brown Trout			Mountain Sucker			Flannelmouth Sucker			Speckled Dace			Totals		
	C*	M*	R*	C*	M*	R*	C*	M*	R*	C*	M*	R*	C*	M*	R*	C*	M*	R*	C*	M*	R*
September 1974																					
P-1										103	59	-				28	27	-	131	86	-
P-2										24	19	-							24	19	-
P-3										4	4	-							4	4	-
P-4										1	-	-							1	-	-
P-5				1	1	-				3	3	-							4	4	-
P-6										18	16	-				6	5	-	24	21	-
P-7										2	2	-				8	8	-	10	10	-
W-3	1	1	-							1	1	-				1	1	-	3	3	-
L.S.L.	78	54	-							-	-	-				-	-	-	78	54	-
Totals	79	55	-	1	1	-				156	104	-				43	41	-	279	201	-
November 1974																					
P-1	1	1	-				1	1	-	44	42	2				4	4	-	50	48	2
P-2										14	13	1							14	13	1
P-3										48	48	-				2	-	-	50	48	-
P-4																2	-	-	2	-	-
P-5										7	7	-							7	7	-
W-3	2	2	-							1	1	-							3	3	-
L.S.L.	15	14	1																15	14	1
WR-2													1	1	-	1	-	-	2	1	-
Totals	18	17	1	-	-	-	1	1	-	114	111	3	1	1	-	9	4	-	143	134	4
January 1975																					
P-2	1	-	-							72	-	-							73	-	-
S-2	36	-	-							11	-	-				15	-	-	62	-	-
L.S.L.	42	-	-	1	-	-										2	-	-	45	-	-
W-3										6	-	-							6	-	-
Totals	79	-	-	1	-	-	-	-	-	89	-	-	-	-	-	17	-	-	186	-	-

Table XI–15 (Continued)

Month and Station	Brook Trout			Rainbow Trout			Brown Trout			Mountain Sucker			Flannelmouth Sucker			Speckled Dace			Totals		
	C*	M*	R*	C*	M*	R*	C*	M*	R*	C*	M*	R*	C*	M*	R*	C*	M*	R*	C*	M*	R*
March 1975																					
P-1	2	-	-							20	-	-				3	-	-	25	-	-
P-2	1	-	-							5	-	-				1	-	-	7	-	-
P-3	2	1	-	1	1	-				2	1	-				12	-	-	17	3	0
P-5										3	-	-				1	-	-	4	-	-
P-5A	2	2	-							5	5	-							7	7	-
P-7													1	1	-				1	1	-
S-2	7	-	-																7	-	-
L.S.L.	74	-	3																74	-	3
W-3										1	-	-							1	-	-
WR-1													5	5	-				5	5	-
Totals	88	3	3	1	1	-	-	-	-	36	6	-	6	6	-	17	-	-	148	16	3
May 1975																					
P-1										1	-	-							1	-	-
P-2	1	-	-							1	-	-							2	-	-
P-3	1	1	-																1	1	-
P-5										1	-	-							1	-	-
P-5A	1	1	-							2	1	-				4	-	-	7	2	-
P-6										1	-	-				1	-	-	2	-	-
S-2	6	6	-																6	6	-
L.S.L.	8	2	-																8	2	-
W-3	2	2	-																2	2	-
Totals	19	12	0	-	-	-	-	-	-	6	1	-	-	-	-	5	-	-	30	13	-
July 1975																					
P-1	2	2	-	-	-	-				42	-	1				35	-	-	79	2	1
P-2	1	1	-	-	-	-				2	2	-				-	-	-	3	3	-
P-3	7	6	1	-	-	-				24	6	-				14	-	-	45	12	1
P-5	-	-	-	-	-	-				4	-	-				-	-	-	4	-	-
P-5A	-	-	-	1	1	0				1	-	-				-	-	-	2	1	-
P-6	-	-	-	-	-	-				2	-	-				-	-	-	2	-	-
P-7	-	-	-	-	-	-				-	-	-				3	-	-	3	-	-
S-2	6	6	-	-	-	-				-	-	-				-	-	-	6	6	-
L.S.L.	7	4	1	-	-	-				-	-	-				-	-	-	7	4	1
Totals	23	19	2	1	1	-	-	-	-	75	8	1	-	-	-	52	-	-	151	28	3

Table XI–15 (Continued)

	Brook Trout			Rainbow Trout			Brown Trout			Mountain Sucker			Flannelmouth Sucker			Speckled Dace			Totals		
	C*	M*	R*	C*	M*	R*	C*	M*	R*	C*	M*	R*	C*	M*	R*	C*	M*	R*	C*	M*	R*
GRAND TOTALS	306	106	6	4	3	-	1	1	-	476	230	4	7	7	-	143	45	-	937	392	10

1. Marking with numbered tags began in May 1975.
2. One mottled sculpin and four mountain whitefish were collected from the White River in March 1975.

* C = Captured, M = Marked, R = Recaptured

Station Legend:
P1-7: Piceance Creek
S1-2: Stewart Creek
L.S.L.: Lower Stewart Lake
W1-3: Willow Creek
WR1-2: White River

(*Cottus bairdi*), and mountain white fish (*Prosopium williamsoni*). Fish species collected in the study streams are listed in Table XI-16. In the vicinity of the Tract, Piceance Creek supports higher populations of fish than are found in Stewart Creek and Willow Creek. These are primarily mountain sucker, speckled dace, and brook trout. A few rainbow trout have been collected in the middle reaches of Piceance Creek.

Differences in numbers of fish occur in various areas of Piceance Creek. The areas with a rock and gravel substrate and a combination of riffles and pools offer better habitat for fish than do other areas. There is a general trend for numbers of fish to increase in an upstream direction. In terms of fish species, the upstream portions of Piceance Creek near the Tract contain more fish than downstream areas.

Mountain suckers are found throughout Piceance Creek, where they spawn in late spring and early summer. Newly hatched fish were collected in July along with spawning fish. Males develop orange bands on their sides and tuberculate caudal and anal fins during spawning. Females also show some coloration. Fecundity studies on female fish indicate several spawnings per year. Ovaries contained equal quantities of ripe and developing eggs. Fecundity estimates for female fish of 129 to 134 millimeters total length ranged from approximately 2600 to 4200 eggs produced per year. More mountain suckers were observed in spawning condition in upstream portions of Piceance Creek than in downstream sections, indicating more favorable spawning conditions may exist upstream. The mountain sucker population in Piceance Creek appears to be well established and thriving. Piceance Creek is thought to be the only known locality for mountain suckers in Colorado. Estimates of abundance of mountain sucker range as high as 68 fish per 100-meter stretch of Piceance Creek in the vicinity of the Tract. Estimates of mountain sucker abundance vary at different locations within Piceance Creek. Estimates computed for mountain sucker abundance range from 23 ± 7 to 68 ± 38 fish per 100-meter stretch of stream depending on station location. Estimates are based on the DeLury method of determining population size. Abundance and confidence intervals are computed by the method outlined by Zippin (1958, Journal Wildlife Management 22(1): 82-90). Scale aging of mountain suckers has determined fish from age groups 0+ to 4+ (Ricker, 1968, IBP Handbook No. 3) comprise the majority of the mountain sucker population. Stomach analyses indicate the major food source to be algae, plant material and some insects.

Speckled dace are sampled with mountain suckers in Piceance Creek. Spawning occurs in late spring and summer. Males develop reddish fins and coloration on the lower jaw during spawning. Speckled dace appear to spawn several times, as eggs examined were not all at the same stage of development. The number of eggs produced by the speckled dace is similar to the number produced by the mountain sucker. Fecundity estimates for female fish of 87 to 109 mm. total length, ranged from approximately 2700 to 7000 eggs per year. Estimates of speckled dace

Table XI–16 FISH COLLECTED FROM PICEANCE CREEK, STEWART CREEK, WILLOW CREEK AND THE WHITE RIVER

Scientific Name[1]	Common Name[1]
Salmo trutta	Brown trout
Salmo gairdneri	Rainbow trout
Salvelinus fontinalis	Brook trout
Prosopium williamsoni	Mountain whitefish
Rhinichthys osculus	Speckled dace
Catostomus latipinnus	Flannelmouth sucker
Catostomus platryhynchus	Mountain sucker
Cottus bairdi	Mottled sculpin

(1) American Fisheries Society. 1970. A List of Common and Scientific Names of Fishes from the United States and Canada. 3rd Ed. Spec. Pub. No. 6.

abundance range from 13 ± 8 to 63 ± 32 fish per 100-meter stretch of Piceance Creek in the vicinity of the Tract, depending on station location.

Brook trout are the predominant trout species in the Tract vicinity. A few rainbow and brown trout have been collected. Brook trout occur in Stewart Creek and in Lower Stewart Lake, and in the channel that drains Lower Stewart Lake. In addition, brook trout occur at some stations in Piceance Creek (Table XI-15). Suitable habitat varies along Piceance Creek, and fish abundance reflects habitat suitability. Brook trout spawn in the fall. Young fingerling brook trout have been collected in the spring in Stewart Creek and Lower Stewart Lake, indicating that natural spawning occurs in the areas. Brook trout feed primarily on stream insects. Estimates of brook trout abundance range from 0 to 10 ± 8 fish per 100-meter stretch of stream in the vicinity of the Tract, depending on station location. Scale aging of brook trout has indicated that most fish captured are in the age groups 0+ and 1+ (Ricker, 1968 IBP Handbook No. 3). Several of the larger fish have been in age group 2+.

The White River at its confluence with Piceance Creek has a river environment comparable to the small stream environment of Piceance Creek. However, cold water fish species are more abundant upstream near headwater regions of the White River than in the vicinity of Piceance Creek. Mottled sculpin is abundant in the White River. In addition, mountain whitefish, flannelmouth suckers, and speckled dace have been collected.

4. Reptiles and Amphibians

Due to their abundance and presumable importance in the biological systems on the Tract, lizards were selected for detailed study of population densities. Mark and recapture techniques are employed to provide data for estimating densities. Each lizard is given an identification number by toe clipping. Noosing combined with pit-can captures are the primary means used to obtain individuals for recapture statistics. Sampling areas include animal grids #1 and #2, and pit-can traps located on each of the grids. Grid lines are walked daily during morning hours when the lizards are at sunning locations. Lizards are marked and released and their capture location noted (i.e., assigned to the nearest stake on the grid lines). Captures are listed by sampling period in Table XI-17. When numbers of reptiles are sufficiently large, density estimates are computed based on the modified Peterson Index (Roff 1973). General reconnaissance on the Tract and nearby areas is employed on a qualitative basis.

During the first year of study on the Tract, five reptiles (including four lizards and one snake) and two amphibians have been observed (Table XI-18). Lizards represent the most abundant group in the current species list.

Table XI–17 REPTILES AND AMPHIBIANS CAPTURED ON GRIDS 1 AND 2 IN JUNE, JULY AND AUGUST 1975

Scientific Name	Common Name	June		July		August	
		Day 1	Day 2	Day 1	Day 2	Day 1	Day 2
GRID 1							
IGUANIDAE							
Phrynosoma douglassi	Short-horned lizard		1				
Sceloporus graciosus	Sagebrush lizard	4	3	7	4	7	6
Sceloporus undulatus	Eastern fence lizard	2			1	1	
Urosaurus ornatus	Tree lizard						1
GRID 2							
AMBYSTOMIDAE							
Ambystoma tigrinum utahensis	Utah tiger salamander	1					
IGUANIDAE							
Sceloporus graciosus	Sagebrush lizard	3	4	18	9	3	3

Table XI–18 REPTILES AND AMPHIBIANS OBSERVED ON TRACT C-b, THROUGH AUGUST 1975

Scientific Name	Common Name
AMBYSTOMIDAE	
Ambystoma tigrinum utahensis	Utah tiger salamander
RANIDAE	
Rana pipiens	Leopard frog
IGUANIDAE	
Phrynosoma douglassi	Short-horned lizard
Sceloporus graciosus	Sagebrush lizard
Sceloporus undulatus	Eastern fence lizard
Urosaurus ornatus	Tree lizard
COLUBRIDAE	
Thamnophis elegans	Western terrestrial garter snake

A total of 77 lizards were captured on both grids (37 on Grid #1 and 40 on Grid #2) during the June-August sampling period. The sagebrush lizard was the most abundant. On Grid #2 (pinyon-juniper) the sagebrush lizard was the only type captured or observed. On Grid #1 (chained pinyon-juniper) the eastern fence lizard, the tree lizard and the short-horned lizard were significantly less abundant than the sagebrush lizard. Population estimates are not given in this report due to an insufficient number of recaptures through the August sampling period.

The western garter snake is the only snake species that has been identified on the Tract. Additional species expected to occur on Tract are the western diamondback and the coach whip snake.

The distribution and species composition of amphibians on and around the Tract is being evaluated mainly by reconnaissance of streams and ponds. Observations and hand captures will provide information on their relative abundance. The two amphibian species observed on the Tract and in surrounding areas are the leopard frog and the Utah tiger salamander.

5. Invertebrates

Invertebrates are an integral part of any biotic community. They provide food sources for larger animals, act as scavengers, decomposers, herbivores and predators and, in many cases, as parasites on other organisms. Figures XI-17 and XI-18 show the insect-plant/animal interactions with respect to habitat and food, respectively. Table XI-18 contains a partial list of invertebrates identified on the Tract.

Data on seasonal abundance and distribution was gathered by several methods. In terrestrial communities soil samples were taken and hand sorted for macro-invertebrates (those visible to the naked eye). The samples were then placed in Berlese funnels. The combination of heat and light on the soil forced the organisms away from the soil surface and into the collecting bottles. The bottles were filled with 70% alcohol to preserve the invertebrates for further identification. Other invertebrates were collected by sweep net and Baermann funnels. Pit-can trapping collecting was used to collect both invertebrates and reptiles.

Microorganisms were identified by culturing various soil samples. Bacteria, fungi, protozoans and some nematodes can be obtained by using these techniques. Aquatic invertebrates were collected with a square-foot Surber sampler.

a. Terrestrial Invertebrates

Terrestrial invertebrates are very common on the Tract. The phyla that are most numerous are the Nematoda, Annelida, Arthropoda and Mollusca. All soil communities contain species from these phyla. No Rotifera, Tardigrada or Protozoa have been collected.

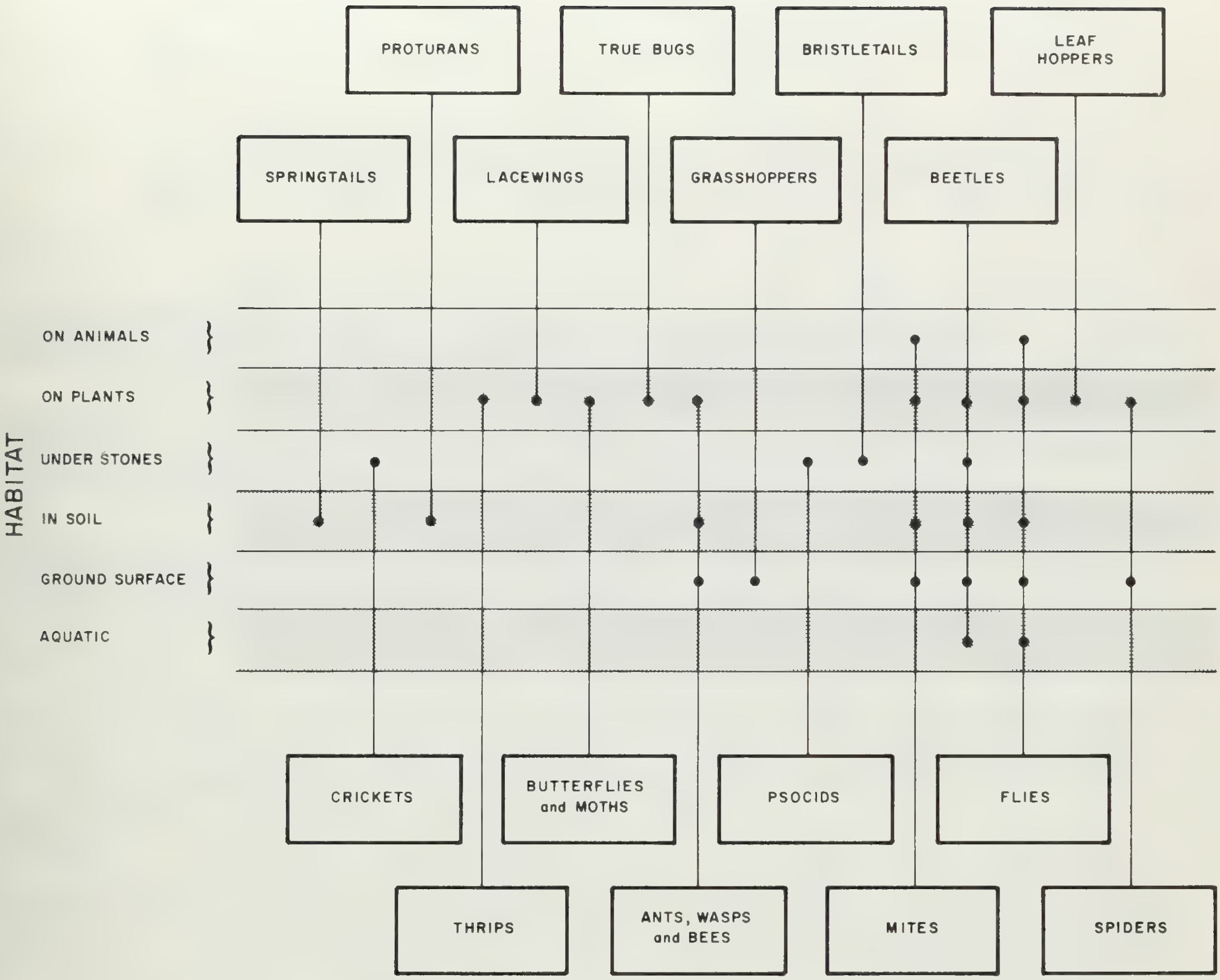


Figure XI–17 INSECT–PLANT/ANIMAL INTERACTIONS (Habitat)

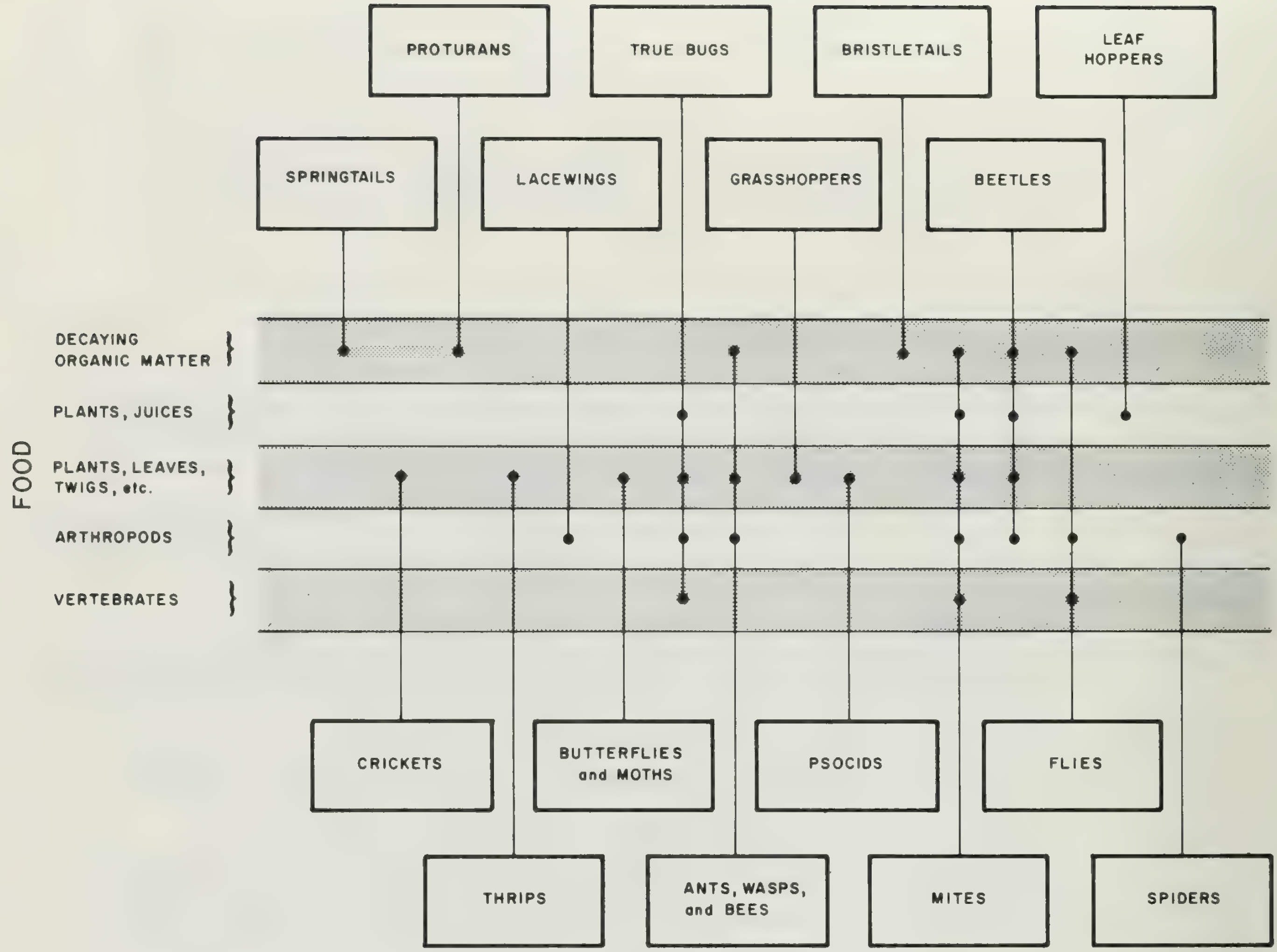


Figure XI–18 INSECT-PLANT/ANIMAL INTERACTIONS (Food)

Phylum Nematoda. Nematodes are probably the most common and abundant organisms in the world. There are free-living and parasitic Nematodes. A measure of their density per acre can aid in determining the productivity of the soil.

Phylum Annelida. The "earthworms" found on Tract all belong to the class Oligochaeta whether they are terrestrial or aquatic. A majority of the terrestrial species belong to the genus Lumbricus. They are important agents in renewing the surface soil.

Phylum Arthropoda. This phylum is the most common of the macroinvertebrates and within this phylum the mites and ticks, or Acarina, are the most numerous on Tract. In terrestrial communities the Archnids, Myriapods and insects are the major terrestrial classes. The Crustacea is the major aquatic class.

Arthropods on the Tract function as herbivores, insectivores and scavengers. There are several types of herbivore relationships present. Some arthropods, such as grasshoppers and leaf beetles eat leaves and tender stems. Others, such as plant bugs, leafhoppers and aphids feed by sucking plant juices from various parts of the plant. This feeding can result in discoloration, wilting, stunting or even death of the plant. Some, for example wasps, affect plants in a manner which causes galls to form.

Some arthropods are insectivores and play important roles in controlling the populations of other arthropods. For example, damsel bugs assassin bugs, parasitic wasps, several spiders, and many other insectivores feed on or attack other arthropods.

Arthropods play an important role as scavengers on decaying plant and animal matter. Bristletails, springtails and ground beetles feed on decaying vegetation. Carrion beetles, rove beetles and blow flies feed on decaying animal matter. These arthropods can dispose of a dead mouse in a matter of days. Without these scavengers, the time required for recycling of decaying organic material would be considerably longer.

Arthropods are an integral part of the biological systems on the Tract and their numbers and diversity of form and habit far exceed those of other animals. Arthropods function at almost all trophic levels. Complex and important relationships exist between arthropods and other plants and animals, including other arthropods. These relationships act as a system of checks and balances that help maintain a stable ecosystem.

Arthropods representing three classes, 15 orders and 70 families were identified from collections on the Tract during May-July 1975 (Table XI-19). This total represents a larger faunal diversity than collected in the September 1974 sampling. In that sampling period, 14

Table XI–19 ANTHROPODS COLLECTED ON TRACT C-b

Scientific Name	Common Name
DIPLOPODA	Millipedes
INSECTA	
THYSANURA	
Machilidae	Jumping bristletails
COLLEMBOLA	
Entomobryidae	Springtails
Sminthuridae	Springtails
ORTHOPTERA	
Acrididae	Short-horned grasshoppers
Tettigoniidae	Long-horned grasshoppers
Gryllacrididae	Crickets
Gryllidae	Crickets
PSOCOPTERA	
Trogiidae	Trogiid booklice
THYSANOPTERA	
Phloeothripidae	Thrips
HEMIPTERA	
Anthocoridae	Minute pirate bugs
Miridae	Plant bugs
Reduviidae	Assassin bugs
Nabidae	Damsel bugs

Table XI–19 (Continued)

Scientific Name	Common Name
HOMOPTERA	
Cicadellidae	Leafhoppers
Psyllidae	Psyllids
Aphididae	Aphids
COLEOPTERA	
Carabidae	Ground beetles
Silphidae	Carrion beetles
Staphylinidae	Rove beetles
Coccinellidae	Ladybird beetles
Chrysomelidae	Leaf beetles
Curculionidae	Snout beetles
DIPTERA	
Culicidae	Mosquitos
Cecidomyiidae	Gall gnats
Dolichopodidae	Long-legged flies
Phoridae	Humpbacked flies
Syrphidae	Syrphid flies
Tephritidae	Fruit flies
Calliphoridae	Blow flies
SIPHONAPTERA	Fleas
HYMENOPTERA	
Braconidae	Braconid wasp
Chalcidoidea	Chalcid wasps
Mutillidae	Velvet ants

Table XI–19 (Continued)

Scientific Name	Common Name
Formicidae	Ants
Pompilidae	Spider wasps
ARACHNIDA	
Opiliones	
PHALANGIDA	
Phalangiidae	
ACARINA	
Protostigmata	Protostig mites
Ixoxides	Tick
Cryptostigmata	Oribatid mites
ARANEIDA	
Dictynidae	Spider
Gnaphosidae	Hunting spiders
Pholicidae	Long-legged spiders
Clubionidae	Two-clawed hunting spiders
Thomisidae	Crab spiders
Salticidae	Jumping spiders
Agelenidae	Funnel-webbed spiders
Hahniidae	Hahniid spiders
Lycosidae	Wolf spiders
Oxyopidae	Lynx spiders
Araneidae	Orb-weavers
Micryphantidae	Dwarf spiders

orders and 50 families had been identified. The higher diversity of arthropods collected in the later sampling period results from a larger sample size; i.e., three months data in 1975 vs. one month of data in 1974. In addition, optimum conditions for many arthropods such as favorable temperature regimes and maximum vegetational productivity in the study area, occured during this sampling period.

Analysis of data from the pit-can traps (Table XI-20) indicates that the chained pinyon-juniper vegetation supports a similar diversity of arthropod fauna as that found in pinyon-juniper. Beetles and spiders appear to be well represented. The number of families collected at the two sites in each month was: May-- 11 (Grid 1), 11 (Grid 2); June-- 16 (Grid 1), 14 (Grid 2); July-- 11 (grid 1), 10 (Grid 2).

Periods of peak activity could not be discerned for the majority of arthropods collected. Many of the most abundant species were represented by approximately the same number of individuals in each of the monthly collections made during the period May-July 1975. Very few exceptions to this trend were observed.

Lepidopterous larvae were particularly abundant during the months of May and June 1975. Sweep net collections showed an activity peak for this group in May while pit-can collections revealed an activity peak in June. Lepidopterous larvae have been reported to be an important part of the diet of both the deer mouse and the least chipmunk. It is expected that a significant portion of the arthropod intake by the deer mouse and least chipmunk on the Tract (see Table XI-9) during the months of May and June consisted of lepidopterous larvae, since the stomach content analysis of these two small rodents verified the intake of a significant number of these larvae.

b. Aquatic Invertebrates

The term "benthos" is used to designate the group of organisims that live on the bottom substrate of bodies of water. Benthic invertebrates are useful as general indicators of the quality of aquatic habitat in the region relative to reproduction of aquatic fauna. Benthos is sampled bi-monthly from all stream and lake stations using a Surber square-foot bottom sampler. The large number of organisms occurring at some sample sites in the Tract drainage indicate a good production potential for aquatic invertebrates.

Benthic invertebrates in the vicinity of the Tract consist primarily of Annelids, Arthropods and Mollusks (Table XI-21). The Arthropods, especially the aquatic insects, are most numerous. The type of organisms which occur suggests a good production of fish food types. The major Arthropod orders utilized as fish food (Diptera, Plecoptera, Tricopters, Coleopters and Ephemeroptera) are represented at all sampling stations. In the vicinity of the Tract, total numbers

Table XI–20 NUMBERS OF GROUND ARTHROPODS COLLECTED IN PIT CANS IN CHAINED PINYON-JUNIPER RANGELAND (GRID #1) AND PINYON-JUNIPER WOODLAND (GRID #2) ON TRACT C-b.

	September 1974		May 1975		June 1975		July 1975		August 1975	
	#1	#2	#1	#2	#1	#2	#1	#2	#1	#2
Orthoptera	6	1	–	2	1	2	8	2	6	–
Coleoptera	3	–	14	13	17	22	22	10	5	3
Lepidoptera	–	–	–	–	5	–	–	–	–	–
Araneida	44	14	9	29	15	22	22	2	7	6
Misc.	28	120	8	5	6	98	4	16	6	7
TOTAL	81	135	31	49	44	144	56	30	24	16

Table XI–21 MACROINVERTEBRATES COLLECTED FROM PICEANCE CREEK, WILLOW CREEK AND THE WHITE RIVER

COMMON NAME		TAXA*
	Phylum	ANNELIDA
Aquatic earthworms	Class	Oligochaeta
Leeches		Hirudinea
	Phylum	ARTHROPODA
	Class	Insecta
Springtails	Order	Collembola
	Family	Isotomidae
	Genus	*Isotomurus*
		Ephemeroptera
		Baetidae
		Ameletus
		Baetis
		Caenis
		Ephemerella
		Pseudocloeon
		Heptageniidae
		Heptagenia
		Rhithrogena
		Stenonema
Damselflies & Dragonflies		Odonata
		Gomphidae
		Gomphus
		Coenagrionidae
		Ischnura
Stoneflies		Plecoptera
		Nemouridae
		Capniinae
		Taeniopteryginae
		Perlodidae
		Isogenus
		Isoperla
True bugs		Hemiptera
		Notonectidae
		Notonecta

Table XI–21 (Continued)

COMMON NAME	TAXA*
True bugs contd.	Corixidae
	Corixinae
Aphids *	Homoptera
	Aphididae
	Fulgoridae
Beetles	Coleoptera
	Gyrinidae
	Gyrinus
	Dryopidae
	Helichus
	Throscinus
	Dytiscidae
	Agabus
	Agabinus
	Hydroporus
	Elmidae
	Neoelmis
	Optioservus
	Ancyronys
	Heterlimnius
	Stenelmis
	Hydrophilidae
	Hydrophilinae
	Paracymus
	Haliplidae
	Haliplus
Caddisflies	Trichoptera
	Rhyacophilidae
	Glossosoma
	Rhyacophila
	Brachycentridae
	Brachycentrus
	Micrasema
	Hydropsychidae
	Hydropsyche
	Macronemem
	Hydroptilidae
	Hydroptila
	Psychomyiidae
	Polycentropus
	Psychomyia
	Molannidae
	Molanna

Table XI–21 (Continued)

COMMON NAME	TAXA
Aquatic caterpillars	Lepidoptera
	Pyralididae
True flies	Diptera
	Anthomyiidae
	Limnophora
	Ceratopogonidae
	Chironomidae
	Chironomus
	Deuterophesiidae
	Deuterophlegia
	Dixidae
	Dixa
	Rhagionidae
	Atherix
	Simuliidae
	Simulium
	Stratiomyidae
	Odontomyia
	Eupharyphus
	Nemotelus
	Psychodidae
	Psychoda
	Tabanidae
	Chrysops
	Tipulidae
	Erioptera
	Hexatoma
	c.f. Pedicia
	Tipula
	Crustacca
Scuds	Amphipoda
	Gammaridae
	Gammarus
	Talitridae
	Hyalella
Water mites	Hydracarina
	MOLLUSCA
Snails	Gastropoda
	Pulmonata
	Physidae
	Physa
	Lymnacidae

Table XI–21 (Continued)

COMMON NAME	TAXA
Clams	Pelecypoda Spaeridae

*Identification

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and biomass of these organisms undergo seasonal fluctuations as shown in Tables XI-22 through XI-25). The greatest abundance of organisms occur in summer and fall with lower levels during winter. The poorest benthic species composition occurs downstream of the Tract in areas of mud and clay substrate which provides poor habitat for benthic fauna.

The lake stations sampled generally provide good production of benthic invertebrates. Suitable habitat for benthos varies along Piceance Creek as reflected by benthos abundance and diversity. The areas with a rock substrate offer better habitat for benthos than do other areas. There appears to be a general trend for numbers of benthos and species diversity to increase in the upstream portions of Piceance Creek. Species diversity indices are given for all stations in Tables XI-26 to XI-29).

Periphyton is the assemblage of microscopic plants and invertebrates that cover the substrate within the streams such as rocks, plants, sediments and other organisms. Periphyton are the most abundant primary producers in the streams. Periphyton are collected from each station by removing glass slides from the holders which have been immersed in the stream for about a month. Samples are examined in the laboratory for species identification, and biomass is determined. Periphyton biomass estimates represent the standing crop or accumulated production over the month-long period that the samples are submerged in the stream.

Algae are the most abundant periphyton and diatoms are the most abundant algae in the samples taken (Table XI-30). Green and bluegreen algae have also been collected. Stations on Willow Creek and the White River generally have the highest species diversity of periphyton genera. Stations on Piceance Creek near the Tract appear to be similar with regard to species diversity; however, the downstream stations on Piceance Creek appear to have the lowest species diversity. Seasonal changes in number of genera collected have been difficult to discern. Some stations show a general increase in numbers while some stations show the opposite trend. The greatest number of genera collected in any month appeared in Willow Creek. The least number of genera collected occurred at the downstream Piceance Creek station.

Piceance Creek stations appear to have the greatest periphyton biomass per unit area. The highest estimate was 84 grams per square meter in Piceance Creek while the lowest estimate was 0.62 grams per square meter in Stewart Creek. Seasonal changes are quite evident. Eight of the 12 stations sampled showed decreased biomass estimates as winter approached. The seasonal decrease was especially evident along Piceance Creek. In general, the greatest number of species did not correspond with the greatest estimate of biomass. Data indicates that Piceance Creek, although slightly lower in species diversity, has the greatest estimates of periphyton biomass. Willow Creek and the

Table XI–22 TOTAL NUMBER, NUMBER OF EACH ORDER, AND TOTAL BIOMASS (gm/ft^2) OF AQUATIC INVERTEBRATES COLLECTED FOR PICEANCE CREEK STATIONS, AUGUST 1974 - JULY 1975

Biomass in gm/ft^2

TAXA	August	September	October	November	December	January	March	May	July
Station P-1									
Diptera	191	60	41	299	44	69	70	7	82
Plecoptera	0	0	3	3	0	0	5	0	0
Tricoptera	14	0	0	0	0	0	0	0	0
Coleoptera	31	2	0	5	0	0	0	0	4
Ephemeroptera	13	14	72	96	0	94	22	5	133
Other	236	5	1	82	6	59	14	27	62
Total No.	485	81	117	485	50	222	111	39	281
Total Biomass	-	-	-	.1358	.0087	.1828	.0938	.0078	
Station P-2									
Diptera	412	24	31	22	209	60	61	4	296
Plecoptera	1	0	0	0	2	0	8	0	0
Tricoptera	0	3	0	0	0	3	1	0	0
Coleoptera	40	0	0	0	1	0	0	0	1
Ephemeroptera	26	92	19	20	13	60	244	54	126
Other	112	12	3	130	139	3	11	42	144
Total No.	591	128	53	172	364	126	325	100	567
Total Biomass		-	-	.0597	.2266	.1027	.3244	.0845	
Station P-3									
Diptera	475	80	89	61	66	183	40	3	162
Plecoptera	0	0	3	5	2	27	25	1	0
Tricoptera	17	0	16	1	0	0	0	0	0
Coleoptera	25	1	0	6	1	5	1	0	10
Ephemeroptera	31	96	150	49	22	179	206	13	148
Other	21	15	2	163	38	0	9	20	1
Total No.	569	192	260	285	129	394	281	37	321
Total Biomass				.2336	.1501	.2236	.3831	.0129	

Table XI–22 (Continued)

TAXA	August	September	October	November	December	January	March	May	July
Station P-4[1]									
Diptera	79	68	12	22					
Plecoptera	0	1	0	1					
Tricoptera	4	27	5	1					
Coleoptera	20	0	1	0					
Ephemeroptera	39	58	88	21					
Other	49	10	2	1					
Total No.	191	164	108	46	-	-	-	-	-
Total Biomass	-	-	-	.0169	-	-	-	-	-
Station P-5									
Diptera	224	35	28	183	24	55	36	1	226
Plecoptera	0	0	2	2	0	18	5	0	0
Tricoptera	0	32	8	0	0	0	0	0	0
Coleoptera	7	6	3	7	0	0	2	0	1
Ephemeroptera	44	66	60	138	18	105	79	27	103
Other	31	33	4	7	14	49	11	46	76
Total No.	306	172	105	337	56	227	133	74	406
Total Biomass	-	-	-	.1089	.010	.1178	.5591	.0332	
Station P-5A[1]									
Diptera				74	80	2	37	7	291
Plecoptera				0	0	0	14	19	1
Tricoptera				0	0	0	0	2	0
Coleoptera				3	0	0	0	1	3
Ephemeroptera				62	10	12	133	46	57
Other				475	8	2	9	18	2
Total No.		-	-	611	98	16	193	93	354
Total Biomass	-	-	-	.3465	.020	.0080	.3796	.2480	

Table XI–22 (Continued)

TAXA	August	September	October	November	December	January	March	May	July
	Station P-6								
Diptera	294	5	1	6	4	4	4	3	100
Plecoptera	1	0	0	0	1	0	1	0	0
Tricoptera	2	0	0	0	0	0	0	0	0
Coleoptera	2	0	0	0	0	0	0	0	0
Ephemeroptera	54	35	21	1	4	48	49	26	1
Other	137	46	3	107	12	17	11	72	100
Total No.	490	85	25	114	21	69	65	101	201
Total Biomass	-	-		.1117	.010	.0283	.0534	.0346	
	Station P-7								
Diptera		1	13	17	5	39	4	15	6
Plecoptera		0	0	0	0	0	5	0	0
Tricoptera		0	0	0	0	0	0	0	0
Coleoptera		0	0	0	0	0	0	0	0
Ephemeroptera		0	1	0	1	5	32	5	9
Other		31	9	17	1	9	40	75	96
Total No.		32	23	34	7	53	81	95	111
Total Biomass	-	-	-	.0145	.004	.0195	.0932	.143	

1 Station P-4 was relocated and designated as P-5A in November, 1974

Table XI–23 TOTAL NUMBER, NUMBER OF EACH ORDER, AND TOTAL BIOMASS (gm/ft^2) OF AQUATIC INVERTEBRATES COLLECTED FOR STEWART CREEK STATIONS, AUGUST 1974 - JULY 1975

Biomass in gm/ft^2

TAXA	August	September	October	November	December	January	March	May	July
Station S-1									
Diptera	179	8	47	4	33	0	50	273	81
Plecoptera	0	8	11	1	1	0	71	90	22
Tricoptera	4	1	2	0	1	0	13	175	72
Coleoptera	3	0	0	0	0	0	0	0	3
Ephemeroptera	17	25	15	2	18	0	67	128	17
Other	554	0	3	13	10	0	6	20	0
Total No.	757	42	78	20	63	0*	207	686	195
Total Biomass	-	0	0	.0706	.020	-	.5932	1.7643	
Station S-2									
Diptera	77	391	38	207	159	60	5	64	69
Plecoptera	24	0	0	0	0	0	0	5	16
Tricoptera	8	2	2	0	0	1	0	2	1
Coleoptera	1	7	1	1	0	0	4	0	5
Ephemeroptera	172	43	0	10	28	2	5	47	34
Other	0	0	3	186	162	41	13	467	30
Total No.	282	443	44	404	349	104	27	585	155
Total Biomass	-	-	-	.0834	.240	-	.0467	.4670	
Station U.S.L.									
Diptera		86	144	0	0	0	0	68	91
Plecoptera		0	0	0	0	0	0	0	0
Tricoptera		0	0	0	0	0	0	0	0
Coleoptera		2	1	4	0	0	0	2	4
Ephemeroptera		144	1600	31	0	0	0	641	11
Other		158	16	0	0	0	0	85	83
Total No.		390	1761	35	0*	0*	0*	796	189
Total Biomass	-	-	-	-	-	-	-	1.8672	

Table XI–23 (Continued)

	Station L.S.L.								
TAXA	August	September	October	November	December	January	March	May	July
Diptera		764	34	89	397	0	862	461	63
Plecoptera		0	0	0	0	0	0	0	0
Tricoptera		7	0	0	0	0	0	0	0
Coleoptera		2	0	0	0	0	1	2	0
Ephemeroptera		10	8	11	24	0	125	230	8
Other		16	7	0	6	7	0	73	2
Total No.		790	41	100	427	7	988	766	73
Total Biomass	-	-	-	-	-	-	.4613	.9990	

* Weather conditions precluded sampling.

Table XI–24 TOTAL NUMBER, NUMBER OF EACH ORDER, AND TOTAL BIOMASS (gm/ft^2) OF AQUATIC INVERTEBRATES COLLECTED FOR WILLOW CREEK STATIONS, AUGUST 1974 - JULY 1975

Biomass in gm/ft^2

TAXA	August	September	October	November	December	January	March	May	July
Station U.W.L.									
Diptera		494	5	56	26	0	152	39	131
Plecoptera		0	0	0	0	0	0	0	0
Tricoptera		0	0	0	0	0	0	0	0
Coleoptera		4	1	0	0	0	0	0	1
Ephemeroptera		218	81	136	15	0	5	10	4
Other		54	30	2	6	0	9	3	45
Total No.		770	117	194	47	0*	166	52	181
Total Biomass	-	-	-	-	-	-	.2150	.1580	
Station L.W.L.[1]									
Diptera				208	18	0	5	50	181
Plecoptera				0	0	0	0	0	0
Tricoptera				0	0	0	0	0	0
Coleoptera				1	16	0	2	7	0
Ephemeroptera				7	14	0	156	111	34
Other				4	32	0	5	14	3
Total No.		-	-	220	80	0*	168	182	218
Total Biomass	-	-	-	-	-	-	.2685	.2135	

* Weather conditions precluded sampling.

1 L.W.L. sampling was begun in November, 1974.

Table XI–24 (Continued)

Biomass in gm/ft^2

Station W-1									
TAXA	August	September	October	November	December	January	March	May	July
Diptera	1219	268	125	295	35	0	37	329	22
Plecoptera	4	0	0	11	19	0	6	38	24
Tricoptera	0	1	0	1	3	0	1	1	0
Coleoptera	1	2	0	1	3	0	0	1	2
Ephemeroptera	1	9	0	92	28	0	62	93	206
Other	2	0	3	83	2	0	2	20	3
Total No.	1227	280	128	483	90	0*	108	482	257
Total Biomass	-	-	-	.090	.3967	-	.0441	.7269	

Station W-2									
Diptera	1033	144	72	121	29	0	1	13	313
Plecoptera	12	2	4	9	4	0	0	12	22
Tricoptera	15	17	1	1	0	0	0	7	2
Coleoptera	1	2	0	0	0	0	0	0	2
Ephemeroptera	0	24	6	18	9	0	32	23	25
Other	19	73	1	32	3	0	0	6	17
Total No.	1080	262	84	181	45	0*	33	61	381
Total Biomass	-	-	-	.4804	.090	-	.0482	.8721	

Station W-3									
Diptera	546	11	56	97	31	18	3	359	196
Plecoptera	0	0	0	3	1	1	0	16	0
Tricoptera	0	1	0	1	0	1	0	0	1
Coleoptera	0	1	1	1	0	0	0	0	4
Ephemeroptera	240	118	8	28	6	29	7	51	7
Other	30	15	85	42	6	32	11	24	118
Total No.	816	146	150	172	44	81	21	450	326
Total Biomass	-	-	-	.6097	.010	.0769	.0641	.6561	

Table XI–25 TOTAL NUMBER, NUMBER OF EACH ORDER, AND TOTAL BIOMASS (gm/ft^2) OF AQUATIC INVERTEBRATES COLLECTED FOR WHITE RIVER STATIONS, AUGUST 1974 - JULY 1975

Biomass in gm/ft^2

	Station WR-1								
TAXA	August	September	October	November	December	January	March	May	July
Diptera	31	36	19	47	32	0	20	0	0
Plecoptera	0	0	30	79	35	0	80	0	0
Tricoptera	45	82	0	69	34	0	10	0	1
Coleoptera	1	0	0	1	3	0	0	0	1
Ephemeroptera	221	94	7	712	154	0	363	0	15
Other	2	0	2	1	0	0	0	0	6
Total No.	300	212	58	909	258	0*	473	0[1]	23
Total Biomass	-	-	-	.0408	.1000	-	.4476	-	
	Station WR-2								
Diptera	401	80	52	513	40	0	31	6	0
Plecoptera	9	2	10	137	5	0	48	9	5
Tricoptera	178	129	15	29	2	0	3	4	2
Coleoptera	0	0	0	0	0	0	0	0	0
Ephemeroptera	1140	264	14	540	49	0	107	79	81
Other		3	0	130	0	0	0	4	0
Total No.	1728	478	91	1346	96	0*	189	102	88
Total Biomass	-	-	-	-	-	-	.1584	.1257	

* Weather conditions precluded sampling

1 High flows prevented sampling

Table XI–26 BENTHIC INVERTEBRATE SPECIES DIVERSITY INDICES FOR PICEANCE CREEK

Month	Station P-1	P-2	P-3	P-4*	P-5	P-5A*	P-6	P-7
September	1.66	2.08	2.59	2.75	3.26	–	1.44	1.00
October	1.49	1.59	2.05	1.36	2.40	–	1.59	1.19
November	2.21	1.40	2.47	2.46	2.20	1.29	0.44	1.42
December	0.67	1.47	2.37	–	2.12	1.16	2.02	1.84
January	1.76	1.82	1.58	–	2.35	1.06	1.27	1.76
March	1.75	1.77	1.65	–	2.24	2.08	1.16	1.49
May	1.62	1.99	2.00	–	1.65	2.80	1.44	0.97
July	1.74	1.76	2.01	–	1.84	1.61	1.82	0.86

*Station P-4 was relocated to P-5A in November 1974.

Table XI–27 BENTHIC INVERTEBRATE SPECIES DIVERSITY INDICES FOR STEWART CREEK AND LAKES

Month	Station S-1	S-2	USL	LSL
September	1.65	2.00	1.95	0.41
October	2.43	2.10	0.58	1.40
November	2.02	2.44	0.51	0.49
December	1.98	2.34	*	0.54
January	**	2.24	*	**
March	2.34	2.65	*	0.56
May	2.52	1.27	0.96	1.48
July	2.74	2.51	1.96	0.67

* Station was frozen over.

** Weather conditions precluded taking samples.

Table XI–28 BENTHIC INVERTEBRATE SPECIES DIVERSITY INDICES
FOR WILLOW CREEK AND WILLOW LAKES

Month	W-1	W-2	Station W-3	UWL	LWL
September	1.95	3.29	1.22	1.34	***
October	2.19	2.31	1.74	1.33	***
November	2.64	2.45	2.99	0.87	0.38
December	3.02	2.65	1.87	1.46	1.99
January	*	*	2.34	**	**
March	1.39	0.50	1.55	0.68	0.50
May	1.64	2.63	1.46	1.39	1.41
July	1.17	1.05	1.23	1.20	0.76

* Stations were frozen over.

** Weather conditions precluded taking samples.

*** Station LWL sampling started in November 1974.

Table XI–29 BENTHIC INVERTEBRATE SPECIES DIVERSITY INDICES
FOR THE WHITE RIVER

Month	Station WR-1	WR-2
September	1.79	1.79
October	1.83	1.75
November	2.88	2.82
December	2.02	2.88
January	*	*
March	1.84	2.21
May	**	2.10
July	2.13	0.55

* Stations were frozen over.

** Unable to sample due to high flow.

Table XI–30 TAXONOMIC LIST OF AQUATIC VEGETATION COLLECTED FROM PICEANCE CREEK, STEWART CREEK, WILLOW CREEK AND THE WHITE RIVER

Scientific Name	Common Name
Chlorophyceae	Green algae
Actinastrum	
Cladophora sp.	
Chaetophora sp.	
Closterium liebleinii	
Closterium lunula	
Closterium gracilis	
Cosmarium sp.	
Enteromorpha sp.	
Microspora sp.	
Pediastrum sp.	
Protococcus viridis	
Protoderma viride	
Scenedesmus sp.	
Spirogyra sp.	
Stigoclonium sp.	
Ulothrix zonata	
Ulothrix sp.	
Vaucheria sp.	
Bacillariophyceae	Diatoms
Achnanthes lanceolata	
Achnanthes lanceolata var. Dubia	
Amphora ovalis	
Amphiprora ornata	
Asterionella sp.	
Caloneis amphisbaena	
Caloneis silicula	
Ceratoneis sp.	
Cocconeis placentula	
Cymbella affinis	
Cymbella ventricosa	
Cymbella tumida	
Cyclotella meneghiniana	
Cymatopleura solea	
Deploneis sp.	
Diatoma vulgare	
Diatoma tenue var. Elongatum	
Eunotia pectinalis	
Fragilaria construens	
Fragilaria crotonensis	
Frustulia sp.	
Gomphoneis sp.	

Table XI–30 (Continued)

Scientific Name	Common Name
Bacillariophyceae (continued)	
Gomphonema olivaceum	
Gomphonema constrictum	
Gyrosigma acuminatum	
Melosira sp.	
Meridion circulare	
Navicula cryptocephala	
Navicula rhynchocephala	
Navicula viridula	
Nedium sp.	
Nitzschia gracilis	
Nitzschia sigmoidea	
Nitzschia acicularis	
Nitzschia palea	
Nitzschia paleacea	
Pinnularia viridis	
Rhoicosphenia curvata	
Rhopalodia sp.	
Stauroneis sp.	
Stephanodiscus hantzschii	
Surirella ovata	
Synedra ulna	
Synedra ulna var. Impressa	
Synedra rupens	
Tabellaria sp.	
Cyanophyta	Blue-green algae
Agmenellum sp.	
Anabaena sp.	
Lyngbya sp.	
Nodularia sp.	
Oscillatoria limnetica	
Oscillatoria limosa	
Oscillatoria sp.	
Phormidium sp.	
Euglenophyceae	Euglenids
Euglena acus	
Tracheophyta	Vascular plants
Najas sp.	Water-nymph
Ranunculus sp.	Buttercup
Potamogeton sp.	Pondweed
Mimulus sp.	Monkey-flower
Rorippa sp.	Watercress

Table XI–30 (Continued)

* Identifications:

1) Smith, G. M. 1950. The fresh-water algae of the United States. 2nd ed. McGraw-Hill Book Co., New York.

2) Ward, H. B. and G. C. Whipple. 1965. Fresh-water biology. 2nd ed. Edited by W. T. Edmondson. Wiley and Sons, New York.

3) Correll, D. S. and H. B. Correll. 1972. Aquatic wetland plants of the Southwestern United States. Environmental Protection Agency, Washington, D. C.

White River are similar in the estimates of periphyton biomass, while Stewart Creek has been the least productive. Periphyton productivity estimates ranged from 0.0086 to 0.3630 gm. ash free wt./day/m^2 in Piceance Creek stations. The highest productivity has occurred in the middle portions of the sampling area (stations P-3, P-5), while the lowest productivity has occurred at the downstream stations (P-6, P-7). In Stewart Creek, periphyton productivity ranged from 0.0058 to 0.1417 gm. ash free wt./day/m^2. In Willow Creek, periphyton productivity ranged from 0.0258 to 0.4433 gm. ash free wt./day/m^2.

As part of the aquatic invertebrate studies, water quality samples are collected bi-monthly at 17 stream and lake stations along Piceance, Stewart and Willow Creeks in the vicinity of the Tract, and at two stations along the White River. Analyses on all samples have been conducted for 31 parameters, as shown on Tables XI-31 through XI-34. Sediment analyses were begun in May, 1975. Analyses are also conducted for four characteristics of sediment.

The total dissolved solids in streams in the vicinity of the Tract is high (about 800 to 1000 ppm), which is typical of streams in the region. Station P-7, located about eight miles downstream of the Tract, has a total dissolved solids content slightly higher than near the Tract, ranging from 1000 to 1500 ppm. The water quality in the White River is better than Piceance Creek, ranging from 200 to 500 ppm of total dissolved solids. Total dissolved solids for the streams studied fluctuate seasonally, with low levels occurring during periods of high flow, as shown in Figures XI-19 to XI-22. The high dissolved solids, along with the high turbidity at times from siltation, results in a habitat of marginal quality.

Water temperatures fluctuate from freezing levels in winter to temperatures around 60° F. in summer, as shown in Figures XI-23 through XI-26. Dissolved oxygen levels (also shown in Figures XI-23 through XI-26) are adequate year round to support aquatic life. coliform levels in the streams in the vicinity of the Tract exceed state water quality standards at certain times of the year. These high coliform levels coincide with intensive cattle and sheep grazing along the streams and with the return of irrigation water to the streams. All of the streams tested are alkaline (pH generally greater than 8). A general degradation of water quality of the streams near the Tract occurs in the downstream direction.

Table XI–31 WATER QUALITY SAMPLE ANALYSES FOR PICEANCE CREEK STATIONS

STATION : P-1

Note: ND = Not Detected

CONSTITUENTS	1974 Aug	1974 Sep	1974 Oct	1974 Nov	1974 Dec	1975 Jan	1975 Mar	1975 May	1975 Jul	1975 Sep	1975 Nov	1976 Jan	1976 Mar	1976 May	1976 Jul
Temperature (°F)	61.0°	56.0°	54.0°	39.2°	32.0°	Frozen	43.0°	46.0°	58.1°						
pH	8.2	8.4	8.3	8.1	8.2	Over	8.3	8.4	8.3						
Dissolved Oxygen (mg/l)	7.0	10.0	11.0	14.9	15.0		15.0	10.5	10.9						
Conductivity (μ ohms/cm)	1075	1125	1200	1200	1280		1200	920	1300						
Total Solids (ppm)	636	716	920	888	728		916	600	770						
Total Alkalinity ($CaCO_3$)(ppm)	320	410	430	390	445		440	370	475						
Total Hardness ($CaCO_3$)(ppm)	260	310	330	290	350		320	291	345						
CATIONS (ppm)															
Calcium (Ca)	22	66	52	52	76		60	60	72						
Magnesium (Mg)	50	35	49	39	39		41	34	40						
Sodium (Na)	120	138	140	148	128		128	75	144						
Potassium (K)	2.8	1.9	3.1	2.5	2.5		2.8	1.7	5.0						
Ammonia (NH_4)	0.89	0	0	0.1	0		0.48	0.06	0.59						
ANIONS (ppm)															
Hydroxide (OH)	0	0	0	0	0		0	0	0						
Carbonate (CO_3)	24	12	6	18	0		0	0	24						
Bicarbonate (HCO_3)	342	476	512	439	543		537	451	531						
Sulfate (SO_4)	166	155	165	152	160		145	83	144						
Chloride (Cl)	25	17	20	25	20		15	8.0	15						
Nitrate (NO_3)	1.4	0.35	0.13	1.6	1.4		0.98	4.4	0.93						
Boron (B)	0.38	0.18	0.17	0.25	0.18		0.26	2.4	0.20						
Silica (SiO_2)	16	14	17	18	18		17	12	18						
Iron (Fe)	0.74	0.83	0.43	1.1	1.3		0.48	29	1.3						
Manganese (Mn)	0	0	0	0	0		0	0	0						
NUTRIENTS (ppm)															
Ortho Phosphate (PO_4)	0.04	0.08	0.05	0.07	0.00		0.08	0.00	0.04						
Nitrite (N)	0	0.001	0	0	0		0	0	0						
Nitrate (N)	0.31	0.08	0.003	0.36	0.31		0.22	0.99	0.21						
Ammonia (N)	0.69	0	0	0.08	0		0.37	0.05	0.46						
MICROBIOLOGY															
Standard Plate Count/ml at 35°C	840	1000	210,000	280,000	170,000		50,000	11,000	130,000						
Coliform MPN/100ml	4600	43	110	23	1100		1100	>24,000	4600						
Fecal Coliform MPN/100ml	43	9	<3	4	23		23	2400	460						
Fecal Streptococci MPN/100ml	-	< 3	93	43	43		280	< 3	240						
Pathogens	-	ND	ND	ND	ND		ND	ND	ND						
SEDIMENT ANALYSIS															
% Moisture								21.6							
% TKN								0.027	0.023						
% COD								0.49	0.63						
% Volatile Solids								1.7							

Table XI–31 (continued)

STATION: P-2

Note. ND = Not Detected

CONSTITUENTS	1974 Aug	1974 Sep	1974 Oct	1974 Nov	1974 Dec	1975 Jan	1975 Mar	1975 May	1975 Jul	1975 Sep	1975 Nov	1976 Jan	1976 Mar	1976 May	1976 Jul
Temperature (°F)	59°	51°	52°	40°	32°	32°	43°	46°	56°						
pH	8.2	8.9	8.2	8.0	8.2	8.3	8.2	8.4	8.3						
Dissolved Oxygen (mg/l)	6	11	11	15	15	15	15	10.3	9.9						
Conductivity (μ ohms/cm)	1025	1225	1300	1490	1490	1000	1400	950	1380						
Total Solids (ppm)	704	756	1016	928	852	928	1008	640	800						
Total Alkalinity ($CaCO_3$)(ppm)	310	410	420	400	465	470	440	358	485						
Total Hardness ($CaCO_3$)(ppm)	240	375	420	360	455	470	420	283	420						
CATIONS (ppm)															
Calcium (Ca)	20	67	70	60	80	88	72	64	88						
Magnesium (Mg)	46	50	60	51	62	61	58	30	49						
Sodium (Na)	136	144	144	144	132	138	132	82	134						
Potassium (K)	2.9	2.0	2.5	2.2	2.3	2.3	2.3	2.5	5.1						
Ammonia (NH_4)	0	0	0.09	0.09	0	0.13	0.36	0	0.27						
ANIONS (ppm)															
Hydroxide (OH)	0	0	0	0	0	0	0	0	0						
Carbonate (CO_3)	24	12	6	12	12	24	0	0	18						
Bicarbonate (HCO_3)	329	476	500	464	543	525	537	437	555						
Sulfate (SO_4)	163	222	262	229	246	277	218	104	191						
Chloride (Cl)	25	19	20	20	20	25	15	9.0	14						
Nitrate (NO_3)	1.6	1.3	2.1	3.3	5.9	4.3	3.7	0.86	1.6						
Boron (B)	0.38	0.15	0.17	0.17	0.18	0.10	0.25	2.8	0.12						
Silica (SiO_2)	16	16	18	18	18	19	16	12	18						
Iron (Fe)	1.1	0.09	0.12	0.40	1.2	0.91	0.91	30	0.84						
Manganese (Mn)	0	0	0	0	0	0	0	0	0						
NUTRIENTS (ppm)															
Ortho Phosphate (PO_4)	0	0	0.02	0	0	0.06	0.08	0	0.04						
Nitrite (N)	0	0.001	0	0.04	0.005	0.008	0	0	0						
Nitrate (N)	0.36	0.03	0.26	0.74	1.3	0.97	0.84	0.19	0.36						
Ammonia (N)	0	0	0.07	0.07	0	0.10	0.28	0	0.21						
MICROBIOLOGY															
Standard Plate Count/ml at 35°C	-	210	93,000	820,000	190,000	20,000	710,000	28,000	35,000						
Coliform MPN/100ml	-	11,000	1500	24,000	280	1100	460	11,000	4600						
Fecal Coliform MPN/100ml	-	9	< 3	< 3	43	23	23	1500	210						
Fecal Streptococci MPN/100ml	-	< 3	21	23	93	7	43	93	21						
Pathogens	-	-	-	-	-	-	-	-	-						
SEDIMENT ANALYSIS															
% Moisture								23.8							
% TKN								0.019	0.017						
% COD								0.37	0.63						
% Volatile Solids								1.3							

Table XI–31 (continued)

STATION: P-3

Note: ND = Not Detected

CONSTITUENTS	1974 Aug	1974 Sep	1974 Oct	1974 Nov	1974 Dec	1975 Jan	1975 Mar	1975 May	1975 Jul	1975 Sep	1975 Nov	1976 Jan	1976 Mar	1976 May	1976 Jul
Temperature (°F)	59°	51°	51°	39°	32°	32°	43°	46°	55°						
pH	8.2	9.0	8.2	8.2	8.2	8.2	8.3	8.5	8.3						
Dissolved Oxygen (mg/l)	6	11	11	15	15	15	15	12.2	15.0						
Conductivity (μ ohms/cm)	1075	1225	1300	1380	1540	850	1350	940	1500						
Total Solids (ppm)	724	764	956	952	920	936	964	692	860						
Total Alkalinity ($CaCO_3$)(ppm)	325	370	430	410	460	425	420	355	490						
Total Hardness ($CaCO_3$)(ppm)	245	340	430	390	460	460	385	290	440						
CATIONS (ppm)															
Calcium (Ca)	22	44	68	68	84	84	64	60	96						
Magnesium (Mg)	46	56	63	53	61	61	56	34	49						
Sodium (Na)	136	141	144	140	140	141	135	80	150						
Potassium (K)	2.9	2.0	2.3	2.3	2.3	2.3	2.3	1.9	5.0						
Ammonia (NH_4)	0	0	0	0.18	0	0.08	0.19	0	0.34						
ANIONS (ppm)															
Hydroxide (OH)	0	0	0	0	0	0	0	0	0						
Carbonate (CO_3)	36	12	12	6	12	12	0	0	24						
Bicarbonate (HCO_3)	323	427	500	488	537	494	512	433	549						
Sulfate (SO_4)	186	232	277	234	275	287	216	116	237						
Chloride (Cl)	20	19	20	25	20	25	15	9.0	14						
Nitrate (NO_3)	2.0	1.7	1.2	2.9	6.2	5.7	3.2	5.3	1.5						
Boron (B)	0.17	0.18	0.18	0.17	0.18	0.20	0.30	2.3	0.15						
Silica (SiO_2)	16	18	18	18	18	19	16	13	18						
Iron (Fe)	1.0	1.3	0.21	1.6	1.2	1.1	1.9	35	1.1						
Manganese (Mn)	0	0	0	0	0	0	0	0	0						
NUTRIENTS (ppm)															
Ortho Phosphate (PO_4)	0	0	0.04	0.04	0.08	0.05	0.06	0	0.06						
Nitrite (N)	0	0.005	0	0.008	0	0	0	0	0						
Nitrate (N)	0.45	0.38	0.26	0.66	1.4	1.3	0.72	1.2	0.33						
Ammonia (N)	0	0	0	0.15	0	0.06	0.14	0	0.26						
MICROBIOLOGY															
Standard Plate Count/ml at 35°C	7600	190	180,000	270,000	190,000	35,000	5,700	41,000	28,000						
Coliform MPN/100 ml	4600	2,400	>24,000	750	750	460	2400	2,100	4600						
Fecal Coliform MPN/100 ml	240	9	< 3	< 3	3	460	240	460	1100						
Fecal Streptococci MPN/100 ml	-	< 3	240	39	9	240	43	< 3	460						
Pathogens	-	ND	ND	ND	ND	ND	ND	ND	ND						
SEDIMENT ANALYSIS															
% Moisture								21.5							
% TKN								0.025	0.015						
% COD								0.86	0.77						
% Volatile Solids								2.1							

Table XI–31 (continued)

STATION: P-4

Note: ND = Not Detected

CONSTITUENTS	1974 Aug	1974 Sep	1974 Oct	1974 Nov	1974 Dec	1975 Jan	1975 Mar	1975 May	1975 Jul	1975 Sep	1975 Nov	1976 Jan	1976 Mar	1976 May	1976 Jul
Temperature (°F)	59°	51°	51°	39°											
pH	8.2	9.1	8.2	8											
Dissolved Oxygen (mg/l)	6	11	11	15											
Conductivity (μ ohms/cm)	1075	1275	1300	1480											
Total Solids (ppm)	758	764	1016	968											
Total Alkalinity ($CaCO_3$) (ppm)	330	365	430	410											
Total Hardness ($CaCO_3$) (ppm)	270	350	430	390											
CATIONS (ppm)															
Calcium (Ca)	28	52	68	68											
Magnesium (Mg)	49	53	63	53											
Sodium (Na)	136	144	156	140											
Potassium (K)	3.1	1.9	2.7	2.3											
Ammonia (NH_4)	0	0	0	0.25											
ANIONS (ppm)															
Hydroxide (OH)	0	0	0	0											
Carbonate (CO_3)	30	12	18	6											
Bicarbonate (HCO_3)	342	421	488	488											
Sulfate (SO_4)	193	236	287	246											
Chloride (Cl)	25	15	20	25											
Nitrate (NO_3)	1.5	1.8	1.2	2.9											
Boron (B)	0.18	0.15	0.17	0.17											
Silica (SiO_2)	61	19	19	18											
Iron (Fe)	0.26	0.60	0.16	1.4											
Manganese (Mn)	0	0	0	0											
NUTRIENTS (ppm)															
Ortho Phosphate (PO_4)	0	0	0	0.17											
Nitrite (N)	0	0.005	0	0.005											
Nitrate (N)	0.34	0.41	0.27	0.65											
Ammonia (N)	0	0	0	0.19											
MICROBIOLOGY															
Standard Plate Count/ml at 35°C	840	-	-	570,000											
Coliform MPN/100ml	>24,000			2400											
Fecal Coliform MPN/100ml	240			9											
Fecal Streptococci MPN/100ml				93											
Pathogens															
SEDIMENT ANALYSIS															
% Moisture															
% TKN															
% COD															
% Volatile Solids															

Table XI–31 (continued)

STATION: P-5

Note: ND = Not Detected

CONSTITUENTS	1974 Aug	1974 Sep	1974 Oct	1974 Nov	1974 Dec	1975 Jan	1975 Mar	1975 May	1975 Jul	1975 Sep	1975 Nov	1976 Jan	1976 Mar	1976 May	1976 Jul
Temperature (°F)	59°	50°	49°	38°	32°	32°	43°	47°	55°						
pH	8.4	9.2	8.3	8.0	8.3	8,3	8.2	8.4	8.3						
Dissolved Oxygen (mg/l)	6	10.0	11.0	15	15	15	15	10.2	10,4						
Conductivity (μ ohms/cm)	1075	1300	1300	1420	1470	690	1420	1000	1650						
Total Solids (ppm)	676	744	1020	984	810	940	1044	676	910						
Total Alkalinity ($CaCO_3$)(ppm)	340	370	440	435	420	390	440	368	540						
Total Hardness ($CaCO_3$)(ppm)	270	350	435	395	410	420	400	310	470						
CATIONS (ppm)															
Calcium (Ca)	22	48	70	66	64	64	60	66	92						
Magnesium (Mg)	52	56	63	56	61	63	61	35	58						
Sodium (Na)	130	138	160	136	*	141	140	85	160						
Potassium (K)	3.5	1.9	2.8	2.5	*	2.5	2.5	2.3	6.2						
Ammonia (NH_4)	0	0	0.06	0.05	0	0	0.40	0	0.55						
ANIONS (ppm)															
Hydroxide (OH)	0	0	0	0	0	0	0	0	0						
Carbonate (CO_3)	36	12	12	18	48	30	0	0	12						
Bicarbonate (HCO_3)	342	427	512	494	415	415	537	449	634						
Sulfate (SO_4)	160	227	287	244	275	305	242	130	240						
Chloride (Cl)	30	15	20	20	20	25	12	10	1.0						
Nitrate (NO_3)	1.9	1.6	1.0	2.9	5.9	6.3	3.2	1.5	15						
Boron (B)	0.25	0.15	0.17	0.17	0.18	0.20	0.29	2.3	0.63						
Silica (SiO_2)	17	19	19	19	18	21	16	14	19						
Iron (Fe)	0.43	1.1	0.21	1.7	*	1.4	3.2	6.6	0.80						
Manganese (Mn)	0	0	0	0	0	0	0	0	0						
NUTRIENTS (ppm)															
Ortho Phosphate (PO_4)	0	0.02	0.05	0.02	0	0.04	0.08	0.02	0,15						
Nitrite (N)	0	0.005	0	0.008	*	0,02	0	0	0						
Nitrate (N)	0.44	0.37	0.23	0.66	1.3	1.4	0,72	0.33	0,27						
Ammonia (N)	0	0	0.05	0.04	0	0	0.31	0	0.43						
MICROBIOLOGY															
Standard Plate Count/ml at 35°C	5100	500	180,000	420,000	*	26,000	29,000	43,000	1500						
Coliform MPN/100ml	4600	1100	2400	2400	*	93	4600	>24,000	4600						
Fecal Coliform MPN/100ml	93	1100	< 3	21	*	93	240	11,000	460						
Fecal Streptococci MPN/100ml	-	<3	200	150	*	23	460	75	2400						
Pathogens															
SEDIMENT ANALYSIS								24,3							
% Moisture								0,028	0,033						
% TKN								0.59	0,79						
% COD								2.0							
% Volatile Solids															

* Sample lost en route to laboratory

Table XI–31 (continued)

STATION : P-5A

Note. ND = Not Detected

CONSTITUENTS	1974					1975						1976			
	Aug	Sep	Oct	Nov	Dec	Jan	Mar	May	Jul	Sep	Nov	Jan	Mar	May	Jul
Temperature (°F)				37°	32°	32°	38°	47°	55°						
pH				8.0	8.2	8.3	8.3	8.4	8.2						
Dissolved Oxygen (mg/l)				15	15	15	15	12.9	10.1						
Conductivity (μ ohms/cm)				1330	1500	690	1580	15	1650						
Total Solids (ppm)				936	856	950	980	640	920						
Total Alkalinity ($CaCO_3$)(ppm)				370	460	435	430	349	540						
Total Hardness ($CaCO_3$)(ppm)				355	440	450	375	329	475						
CATIONS (ppm)															
Calcium (Ca)				48	72	74	68	70	92						
Magnesium (Mg)				57	63	64	61	37	60						
Sodium (Na)				140	140	147	132	88	170						
Potassium (K)				2.5	2.5	2.5	2.5	3.6	6.8						
Ammonia (NH_4)				0.07	0	0	0.21	0	0.34						
ANIONS (ppm)															
Hydroxide (OH)				0	0	0	0	0	0						
Carbonate (CO_3)				18	0	12	0	0	0						
Bicarbonate (HCO_3)				415	561	506	525	426	659						
Sulfate (SO_4)				257	249	308	183	137	267						
Chloride (Cl)				20	20	30	10	10	15						
Nitrate (NO_3)				2.9	5.4	4.6	2.7	4.2	1.2						
Boron (B)				0.50	0.18	0.30	0.36	2.3	0.44						
Silica (SiO_2)				15	18	20	17	13	20						
Iron (Fe)				0.70	0.57	0.53	2.1	12	0.38						
Manganese (Mn)				0	0	0	0	0	0						
NUTRIENTS (ppm)															
Ortho Phosphate (PO_4)				0.21	0	0	0.09	0.02	0.13						
Nitrite (N)				0.04	0.008	0.014	0	0.01	0						
Nitrate (N)				0.66	1.2	1.0	0.60	0.96	0.27						
Ammonia (N)				0.05	0	0	0.16	0	0.26						
MICROBIOLOGY															
Standard Plate Count/ml at 35°C				180,000	555,000	36,000	81,000	253,000	18,000						
Coliform MPN/100ml				460	93	93	1100	11,000	240						
Fecal Coliform MPN/100ml				43	43	93	23	1100	43						
Fecal Streptococci MPN/100ml				93	4	43	93	43	93						
Pathogens															
SEDIMENT ANALYSIS								29.8							
% Moisture								0.074	0.071						
% TKN								0.92	0.62						
% COD								2.6							
% Volatile Solids															

Table XI–31 (continued)

STATION : P-6

Note: ND = Not Detected

CONSTITUENTS	1974 Aug	1974 Sep	1974 Oct*	1974 Nov	1974 Dec*	1975 Jan	1975 Mar*	1975 May*	1975 Jul	1975 Sep	1975 Nov	1976 Jan	1976 Mar	1976 May	1976 Jul
Temperature (°F)	57°	47°	50°	44°	41°		42°	50°							
pH	8.4	8.8	7.8	8.3	8.3		8.7	-							
Dissolved Oxygen (mg/l)	6	10	9.0	-	11.2		9.0	8.0							
Conductivity (μ ohms/cm)	1075	1475	1550	1800	1200		1225	950							
Total Solids (ppm)	680	880	1030	1164				639							
Total Alkalinity ($CaCO_3$)(ppm)	365	415	542	465	463		455	377							
Total Hardness ($CaCO_3$)(ppm)	310	400		505											
CATIONS (ppm)															
Calcium (Ca)	32	58	83	70	87		82	63							
Magnesium (Mg)	56	62	78	80	66		70	46							
Sodium (Na)	144	159	170	178	140		130	100							
Potassium (K)	3.5	2.0	4.3	2.5	2.6		3.9	3.5							
Ammonia (NH_4)	0	0		0.32											
ANIONS (ppm)															
Hydroxide (OH)	0	0	-	0	-		-	-							
Carbonate (CO_3)	48	12	-	18	0		39	0							
Bicarbonate (HCO_3)	348	482	661	531	565		475	460							
Sulfate (SO_4)	218	277	330	389	280		260	170							
Chloride (Cl)	30	15	14	20	12		14	11							
Nitrate (NO_3)	1.6	0.80	-	2.3	2.8		2.9	3.0							
Boron (B)	0.18	0.18	0.230	0.42	0.220		0.160	0.14							
Silica (SiO_2)	18	20	19	22	16		13	15							
Iron (Fe)	0.19	1.3	0.030	12	0.110		0.030	0.030							
Manganese (Mn)	0	0	0.170	0	0.040		0.030	0.010							
NUTRIENTS (ppm)															
Ortho Phosphate (PO_4)	0.07	0	0.12	0.22	0.06		0.09	0.06							
Nitrite (N)	0	0.003	-	0.025	0.01		0.01	0							
Nitrate (N)	0.37	0.18	-	0.51	0.64		0.66	0.68							
Ammonia (N)	0	0	-	0.29											
MICROBIOLOGY															
Standard Plate Count/ml at 35°C	5100	220													
Coliform MPN/100ml	4600	2,400													
Fecal Coliform MPN/100ml	93	460			3		12								
Fecal Streptococci MPN/100ml	-	<3													
Pathogens															
SEDIMENT ANALYSIS															
% Moisture								27.8							
% TKN								0.035							
% COD								1.1							
% Volatile Solids								2.0							

* U.S.G.S. Data

Table XI–31 (continued)

STATION: P-7

Note: ND = Not Detected

CONSTITUENTS	1974 Aug	1974 Sep	1974 Oct	1974 Nov	1974 Dec	1975 Jan	1975 Mar	1975 May	1975 Jul	1975 Sep	1975 Nov	1976 Jan	1976 Mar	1976 May	1976 Jul
Temperature (°F)	-	46°	40°	32°	32°	Frozen	36°	48°	56°						
pH		8.8	8.4	8.3	8.3	Over	8.0	8.2	8.3						
Dissolved Oxygen (mg/l)		10	11	15	15		15	10.3	10.4						
Conductivity (μ ohms/cm)		2800	720	1075	1700		1730	1350	2600						
Total Solids (ppm)		1524	1500		1032		1152	884	1400						
Total Alkalinity ($CaCO_3$) (ppm)		620	565		440		510	445	710						
Total Hardness ($CaCO_3$) (ppm)		680	605		490		520	420	660						
CATIONS (ppm)															
Calcium (Ca)		70	84		82		76	71	100						
Magnesium (Mg)		123	96		69		19	59	100						
Sodium (Na)		280	224		164		172	120	292						
Potassium (K)		3.5	31		2.5		2.7	2.5	8.4						
Ammonia (NH_4)		0	0.03		0		0.33	0	0.49						
ANIONS (ppm)															
Hydroxide (OH)		0	0		0		0	0	0						
Carbonate (CO_3)		36	36		12		0	12	30						
Bicarbonate (HCO_3)		683	616		512		622	519	805						
Sulfate (SO_4)		575	498		389		338	233	539						
Chloride (Cl)		24	25		20		14	12	19						
Nitrate (NO_3)		0.40	0.44		2.3		2.1	5.4	0.40						
Boron (B)		0.28	0.17		0.27		0.56	2.3	0.98						
Silica (SiO_2)		21	21		20		20	16	16						
Iron (Fe)		2.5	1.3		3.0		6.2	35	8.5						
Manganese (Mn)		0	0		0		0	0	0						
NUTRIENTS (ppm)															
Ortho Phosphate (PO_4)		0.14	0.07		0		0.19	0.04	0.30						
Nitrite (N)		0.006	0		0		0.023	0	0.008						
Nitrate (N)		0.09	0.10		0.51		0.48	1.2	0.09						
Ammonia (N)		0	0.02		0		0.26	0	0.38						
MICROBIOLOGY															
Standard Plate Count/ml at 35°C		110	300,000	590,000	3,200,000		4,390	48,000	21,000						
Coliform MPN/100 ml		390	24,000	>24,000	24,000		2400	>24,000	2400						
Fecal Coliform MPN/100 ml		<3	< 3	93	43		23	2,400	750						
Fecal Streptococci MPN/100 ml		<3	240	240	1100		460	460	460						
Pathogens		ND	ND	ND	ND		ND	ND	ND						
SEDIMENT ANALYSIS															
% Moisture								25.0							
% TKN								0.032	0.015						
% COD								0.72	5.93						
% Volatile Solids								2.0							

Table XI–32 WATER QUALITY SAMPLE ANALYSES FOR STEWART CREEK STATIONS

STATION: S-1

Note: ND = Not Detected

CONSTITUENTS	1974 Aug	Sep	Oct *	Nov *	Dec	1975 Jan	Mar	May*	Jul	Sep	Nov	1976 Jan	Mar	May	Jul
Temperature (°F)	57°		48°	43°	34°	33°	54°	51°							
pH	9.0	8.3	7.8	7.4	8.4	7.2	8.4	8.1							
Dissolved Oxygen (mg/l)	6		8.4	10.5	9.9	10.6	10.4	10.0							
Conductivity (µ ohms/cm)	1400	1550	1400	1750	1300	1400	1300	1350							
Total Solids (ppm)	980	884	921	1160	963	953	958	939							
Total Alkalinity ($CaCO_3$)(ppm)	330	350	422	641	472	418	422	394							
Total Hardness ($CaCO_3$)(ppm)	460	495													
CATIONS (ppm)															
Calcium (Ca)	38	72	95	89	96	93	97	93							
Magnesium (Mg)	89	77	70	64	77	76	86	80							
Sodium (Na)	160	136	120	250	130	120	120	120							
Potassium (K)	2.5	0.9	1.9	2.4	1.4	1.7	1.6	1.5							
Ammonia (NH_4)	0	0	-	-	0.09	0.04	0.04	0.01							
ANIONS (ppm)															
Hydroxide (OH)	0	0													
Carbonate (CO_3)	36	12	-	-	0	0	38	0							
Bicarbonate (HCO_3)	329	403	514	782	575	510	437	480							
Sulfate (SO_4)	442	377	350	330	340	380	370	380							
Chloride (Cl)	20	10	6.6	16.0	11.0	6.7	7.0	6.6							
Nitrate (NO_3)	1.2	4.6	-	-	7.5	7.9	8.0	6.6							
Boron (B)	0	0.17	110	530	260	120	80	80							
Silica (SiO_2)	19	16	17	16	15	15	14	14							
Iron (Fe)	0.05	0.02	20	20	10	10	20	20							
Manganese (Mn)	0	0	0	0	0	10	30	8							
NUTRIENTS (ppm)															
Ortho Phosphate (PO_4)	0.04	0	0	0.03	0.03	0.03	0.09	0.09							
Nitrite (N)	0	0.006	-	-	0	0.01	0	0							
Nitrate (N)	0.28	1.1	-	-	1.7	1.8	1.8	1.5							
Ammonia (N)	0	0	-	-											
MICROBIOLOGY															
Standard Plate Count/ml at 35°C	-	530													
Coliform MPN/100 ml		240													
Fecal Coliform MPN/100 ml		<3	-	-	-	-	-	-							
Fecal Streptococci MPN/100 ml		<3													
Pathogens															
SEDIMENT ANALYSIS															
% Moisture								26.2							
% TKN								0.042							
% COD								0.70							
% Volatile Solids								1.8							

* U.S.G.S. Data

Table XI–32 (continued)

STATION: S-2

Note: ND = Not Detected

CONSTITUENTS	1974 Aug	1974 Sep	1974 Oct	1974 Nov	1974 Dec	1975 Jan	1975 Mar	1975 May	1975 Jul	1975 Sep	1975 Nov	1976 Jan	1976 Mar	1976 May	1976 Jul
Temperature (°F)	59°	-	50°	37°	32°	Frozen	43°	46°	53°						
pH	9.0	8.3	8.4	8.0	8.4		8.3	8.2	8.0						
Dissolved Oxygen (mg/l)	7		11	15	15		15	13.4	10.2						
Conductivity (μ ohms/cm)	1425	1600	1525	1750	1670		1550	1700	2000						
Total Solids (ppm)	876	920	056	1076	992		996		1100						
Total Alkalinity ($CaCO_3$) (ppm)	295	390	425	430	370		370	449	480						
Total Hardness ($CaCO_3$) (ppm)	425	500	550	520	550		490	570	640						
CATIONS (ppm)								1048							
Calcium (Ca)	44	96	98	86	92		78	102	128						
Magnesium (Mg)	77	63	74	74	78		72	77	78						
Sodium (Na)	147	135	140	156	136		140	128	174						
Potassium (K)	1.4	1.4	1.7	2.0	1.5		1.7	1.4	4.9						
Ammonia (NH_4)	0	0	0.52	0.39	0		0.32	0.29	0.53						
ANIONS (ppm)															
Hydroxide (OH)	0	0	0	0	0		0	0	0						
Carbonate (CO_3)	18	12	30	24	30		24	12	0						
Bicarbonate (HCO_3)	323	451	458	476	378		403	523	586						
Sulfate (SO_4)	384	394	383	410	404		354	396	461						
Chloride (Cl)	35	10	15	15	15		10	8.0	8.9						
Nitrate (NO_3)	4.7	2.7	4.9	8.9	19		8.9	2.9	3.0						
Boron (B)	0	0.08	0.17	18	17		12	15	0.24						
Silica (SiO_2)	16	15	17	18	17		12	15	18						
Iron (Fe)	0	0.02	0.03	0.44	0.33		0.89	3.0	0.50						
Manganese (Mn)	0	0	0	0	0		0	0	0						
NUTRIENTS (ppm)															
Ortho Phosphate (PO_4)	0.02	0	0.03	0.04	0.16		0.04	0	0.08						
Nitrite (N)	0.01	0.006	0	0.008	0.009		0.005	0.017	0.008						
Nitrate (N)	1.1	0.61	1.1	2.0	4.3		2.0	0.65	0.67						
Ammonia (N)	0	0	0.40	0.30	0		0.25	0.23	0.41						
MICROBIOLOGY															
Standard Plate Count/ml at 35°C	-	200	350,000	1,000,000	910,000		92,000	53,000	230,000						
Coliform MPN/100 ml		1100	>24,000	1200	4600		1500	4600	11,000						
Fecal Coliform MPN/100 ml		<3	< 3	70	< 3		240	< 3	93						
Fecal Streptococci MPN/100 ml		<3	93	200	15		43	< 3	460						
Pathogens															
SEDIMENT ANALYSIS															
% Moisture								26.1							
% TKN								0.032	0.047						
% COD								0.56	1.28						
% Volatile Solids								1.2							

Table XI–32 (continued)

STATION : L.S.L.

Note: ND = Not Detected

CONSTITUENTS	1974 Aug	1974 Sep	1974 Oct	1974 Nov	1974 Dec	1975 Jan	1975 Mar	1975 May	1975 Jul	1975 Sep	1975 Nov	1976 Jan	1976 Mar	1976 May	1976 Jul
Temperature (°F)	59°	48°	48°	46°	-	46°	45°	47°	55°						
pH	7.4	8.6	8.4	5.5	5.7	8.2	8.4	7.7	8.0						
Dissolved Oxygen (mg/l)	7	12	7.0	12.1		9	12	14.4	10.3						
Conductivity (μ ohms/cm)	1600	1325	1425	1500	1430	1450	1600	1600	1720						
Total Solids (ppm)	848	888	948	984	976	980	1020	992	820						
Total Alkalinity ($CaCO_3$)(ppm)	240	360	420	370	410	390	400	410	430						
Total Hardness ($CaCO_3$)(ppm)	360	500	550	485	390	560	490	558	560						
CATIONS (ppm)															
Calcium (Ca)	20	80	96	94	58	84	92	98	108						
Magnesium (Mg)	75	73	75	61	69	85	63	76	70						
Sodium (Na)	134	129	140	128	136	132	140	116	140						
Potassium (K)	1.9	1.4	1.7	1.7	1.5	1.7	1.7	1.4	4.0						
Ammonia (NH_4)	0.41	0	0.55	0	0	0	0.36	0.36	0.43						
ANIONS (ppm)															
Hydroxide (OH)	0	0	0	0	0	0	0	0	0						
Carbonate (CO_3)	24	12	30	18	36	18	24	0	0						
Bicarbonate (HCO_3)	244	415	451	415	427	439	439	500	525						
Sulfate (SO_4)	376	410	375	376	239	409	356	361	376						
Chloride (Cl)	15	10	15	15	20	20	12	7.0	8.4						
Nitrate (NO_3)	3.5	3.5	7.1	13	19	16	9.8	10	20						
Boron (B)	0.03	0.08	0.17	0.17	0.18	0.30	0.19	0.30	0.51						
Silica (SiO_2)	18	17	17	18	16	18	16	13	17						
Iron (Fe)	0.11	0	0.04	0.14	0.01	0.63	0.18	0.05	0.08						
Manganese (Mn)	0	0	0	0	0	0	0	0	0						
NUTRIENTS (ppm)															
Ortho Phosphate (PO_4)	0	0	0.05	0.06	0.02	0	0.08	0	0.08						
Nitrite (N)	0.015	0.006	0.008	0	0.023	0.010	0.010	0.008	0						
Nitrate (N)	0.79	0.79	1.6	2.9	4.3	3.6	2.2	2.3	4.6						
Ammonia (N)	0.32	0	0.43	0	0	0	0.28	0.28	0.33						
MICROBIOLOGY															
Standard Plate Count/ml at 35°C	1500	110	3200	550,000	230	2500	67,000	410,000	1100						
Coliform MPN / 100 ml	2400	43	7	1100	9	<3	93	750	< 3						
Fecal Coliform MPN / 100 ml	4	4	< 3	<3	< 3	<3	< 3	<3	< 3						
Fecal Streptococci MPN / 100 ml	-	<3	< 3	4	< 3	9	280	<3	< 3						
Pathogens															
SEDIMENT ANALYSIS															
% Moisture								25.0							
% TKN								0.073	0.16						
% COD								1.1	4.53						
% Volatile Solids								2.9							

Table XI–32 (continued)

STATION : U.S.L.

Note: ND = Not Detected

CONSTITUENTS	1974 Aug	1974 Sep	1974 Oct	1974 Nov	1974 Dec	1975 Jan	1975 Mar	1975 May	1975 Jul	1975 Sep	1975 Nov	1976 Jan	1976 Mar	1976 May	1976 Jul
Temperature (°F)	61°	52°	50°	FROZEN	FROZEN	FROZEN	FROZEN	52°	61°						
pH	7.8	8.9	8.2	OVER	OVER	OVER	OVER	8.2	8.3						
Dissolved Oxygen (mg/l)	4	12.0	13.0					14.0	10.2						
Conductivity (μ ohms/cm)	1400	1600	1525					1730	1780						
Total Solids (ppm)	940	1024	1064					1088	880						
Total Alkalinity ($CaCO_3$)(ppm)	320	370	400					426	415						
Total Hardness ($CaCO_3$)(ppm)	480	620	620					578	580						
CATIONS (ppm)															
Calcium (Ca)	56	92	108					90	100						
Magnesium (Mg)	83	95	85					86	80						
Sodium (Na)	144	138	140					136	150						
Potassium (K)	17	1.7	2.0					1.4	4.5						
Ammonia (NH_4)	0.95	0	0.64						0.61						
ANIONS (ppm)															
Hydroxide (OH)	0	0	0					0	0						
Carbonate (CO_3)	12	12	0					18	24						
Bicarbonate (HCO_3)	366	427	488					483	458						
Sulfate (SO_4)	438	490	459					396	430						
Chloride (Cl)	19	15	15					8.0	8.4						
Nitrate (NO_3)	0.52	4.2	4.0					0.94	0.09						
Boron (B)	0	0.08	0.17					0.62	0.44						
Silica (SiO_2)	14	13	15					3.4	13						
Iron (Fe)	0.07	0	0.04					0.05	0.23						
Manganese (Mn)	0	0	0					0	0						
NUTRIENTS (ppm)															
Ortho Phosphate (PO_4)	0	0	0					0	0.02						
Nitrite (N)	0	0.006	0.025					0.023	0						
Nitrate (N)	0.12	0.94	0.91					0.21	0.02						
Ammonia (N)	0.74	0	0.49					0.38	0.47						
MICROBIOLOGY															
Standard Plate Count/ml at 35°C	1600	320	4000					9400	1100						
Coliform MPN/100ml	1500	240	< 3					1100	1500						
Fecal Coliform MPN/100ml	< 3	<3	< 3					< 3	7						
Fecal Streptococci MPN/100ml	-	<3	< 3					< 3	22						
Pathogens	-	ND	ND					-	-						
SEDIMENT ANALYSIS															
% Moisture								39.8							
% TKN								0.14	0.16						
% COD								2.4	4.67						
% Volatile Solids								3.7							

Table XI–33 WATER QUALITY SAMPLE ANALYSES FOR WILLOW CREEK STATIONS

STATION : W-1

Note: ND = Not Detected

CONSTITUENTS	1974 Aug	1974 Sep	1974 Oct	1974 Nov	1974 Dec	1975 Jan	1975 Mar	1975 May	1975 Jul	1975 Sep	1975 Nov	1976 Jan	1976 Mar	1976 May	1976 Jul
Temperature (°F)	39°	44°	43°	32°	36°	FROZEN	37°	46°	53°						
pH	7.1	8.8	8.2	8.2	8.2	OVER	8.0	8.1	8.3						
Dissolved Oxygen (mg/l)	8	10	11	15	15		15	8.1	13.2						
Conductivity (μ ohms/cm)	1325	1300	1375	1075	1440		1450	1450	1600						
Total Solids (ppm)	732	924	880	852	860		864	860	840						
Total Alkalinity ($CaCO_3$)(ppm)	265	390	370	350	360		410	415	460						
Total Hardness ($CaCO_3$)(ppm)	365	480	360	450	490		470	510	536						
CATIONS (ppm)															
Calcium (Ca)	44	68	54	89	96		96	99	124						
Magnesium (Mg)	62	75	55	58	61		58	64	59						
Sodium (Na)	116	114	156	108	104		120	104	134						
Potassium (K)	2.3	1.5	1.9	1.4	1.4		1.5	1.1	4.0						
Ammonia (NH_4)	0	0	0.52	0.13	0		0.34	0.49	0.30						
ANIONS (ppm)															
Hydroxide (OH)	0	0	0	0	0		0	0	0						
Carbonate (CO_3)	18	12	24	12	6.0		0	12	36						
Bicarbonate (HCO_3)	287	451	403	403	427		500	482	488						
Sulfate (SO_4)	315	365	266	313	326		270	289	318						
Chloride (Cl)	25	15	30	15	20		15	10	12						
Nitrate (NO_3)	0.75	1.7	2.0	2.4	2.8		3.8	2.0	0.18						
Boron (B)	0	0.13	0.67	0.08	0.18		0.27	0.27	0.20						
Silica (SiO_2)	18	19	17	16	17		18	10	15						
Iron (Fe)	0.02	0	0.31	0.94	0.11		0.63	0.13	0.14						
Manganese (Mn)	0	0	0	0	0		0	0	0						
NUTRIENTS (ppm)															
Ortho Phosphate (PO_4)	0.05	0.22	0	0	0		0.06	0	0						
Nitrite (N)	0.005	0.006	0	0.008	0.005		0	0.008	0						
Nitrate (N)	0.17	0.37	0.46	0.55	0.62		0.86	0.45	0.04						
Ammonia (N)	0	0	0.40	0.10	0		0.27	0.39	0.23						
MICROBIOLOGY															
Standard Plate Count/ml at 35°C	340	1300	*TNTC	200,000	710,000		63,000	24,000	19,000						
Coliform MPN/100 ml	4600	4600	1100	1100	750		4600	4600	>24,000						
Fecal Coliform MPN/100 ml	93	< 3	< 3	23	< 3		240	< 3	750						
Fecal Streptococci MPN/100 ml	-	< 3	240	43	21		1500	< 3	150						
Pathogens		ND	ND	ND	ND		ND	ND	ND						
SEDIMENT ANALYSIS															
% Moisture								37.0							
% TKN								0.16	0.029						
% COD								2.2	0.62						
% Volatile Solids								2.8							

*Too numerous to count

Table XI–33 (continued)

STATION : W-2

Note: ND = Not Detected

CONSTITUENTS	1974 Aug	1974 Sep	1974 Oct	1974 Nov	1974 Dec	1975 Jan	1975 Mar	1975 May	1975 Jul	1975 Sep	1975 Nov	1976 Jan	1976 Mar	1976 May	1976 Jul
Temperature (°F)	54°	48°	49°	38°	38°	FROZEN	37°	46°	52°						
pH	6.9	8.8	8.2	5.5	8.2	OVER	8.3	8.3	8.3						
Dissolved Oxygen (mg/l)	8	10.0	10.0	15	15		15	11	10						
Conductivity (μ ohms/cm)	1350	1475	1400	1550	1590		1330	1500	1680						
Total Solids (ppm)	820	880	944	940	932		916	892	930						
Total Alkalinity ($CaCO_3$) (ppm)	300	350	380	390	420		360	430	480						
Total Hardness ($CaCO_3$) (ppm)	400	480	500	500	530		415	526	580						
CATIONS (ppm)															
Calcium (Ca)	42	69	76	88	110		76	94	128						
Magnesium (Mg)	72	75	75	68	62		55	71	63						
Sodium (Na)	140	128	132	128	120		116	112	142						
Potassium (K)	2.2	1.7	2.0	1.7	1.4		1.7	1.2	4.0						
Ammonia (NH_4)	0.23	0	0.47	0.14	0		0.39	0.24	0.36						
ANIONS (ppm)															
Hydroxide (OH)	0	0	0	0	0		0	0	0						
Carbonate (CO_3)	30	12	18	18	12		12	12	12						
Bicarbonate (HCO_3)	305	403	427	439	488		415	500	561						
Sulfate (SO_4)	366	348	361	334	339		259	302	328						
Chloride (Cl)	20	20	20	20	20		11	10	11						
Nitrate (NO_3)	0.64	0.62	1.3	1.5	1.5		2.0	0.86	0.71						
Boron (B)	0	0.17	0.17	0.02	0.18		0.16	0.33	0.29						
Silica (SiO_2)	17	18	19	19	17		16	9.6	18						
Iron (Fe)	0.04	0	0.12	0.72	0.54		0.90	4.5	0.37						
Manganese (Mn)	0	0	0	0	0		0	0	0						
NUTRIENTS (ppm)															
Ortho Phosphate (PO_4)	0.04	0.02	0.02	0	0.04			0	0.04						
Nitrite (N)	0.006	0.015	0	0	0.01		0.017	0	0						
Nitrate (N)	0.14	0.14	0.30	0.33	0.34		0.46	0.19	0.16						
Ammonia (N)	0.18	-	0.37	0.11	0		0.30	0.19	0.28						
MICROBIOLOGY															
Standard Plate Count/ml at 35°C	95	460	13,000	320,000	19,000		53,000	65,000	150,000						
Coliform MPN/100 ml	240	1200	460	>24,000	4600		4600	>24,000	24,000						
Fecal Coliform MPN/100 ml	23	< 3	< 3	< 3	< 3		240	460	93						
Fecal Streptococci MPN/100 ml	-	< 3	150	240	23		240	28	210						
Pathogens															
SEDIMENT ANALYSIS															
% Moisture								20.7							
% TKN								0.024	0.025						
% COD								0.36	0.49						
% Volatile Solids								2.0							

Table XI–33 (continued)

STATION: W-3

Note: ND = Not Detected

CONSTITUENTS	1974 Aug	1974 Sep	1974 Oct	1974 Nov	1974 Dec	1975 Jan	1975 Mar	1975 May	1975 Jul	1975 Sep	1975 Nov	1976 Jan	1976 Mar	1976 May	1976 Jul
Temperature (°F)	54°	48°	50°	43°	37°	36°	37°	46°	52°						
pH	6.7	8.8	8.0	5.5	8.2	8.3	8.2	8.1	8.2						
Dissolved Oxygen (mg/l)	8	9.0	10	15	15	15	15	13.3	12.6						
Conductivity (μ ohms/cm)	1425	1500	14.75	1700	1670	525	1550	1750	1800						
Total Solids (ppm)	792	740	976	1032	964	1024	972	1064	940						
Total Alkalinity ($CaCO_3$)(ppm)	295	310	405	430	410	435	410	490	495						
Total Hardness ($CaCO_3$)(ppm)	390	410	520	535	530	580	500	616	600						
CATIONS (ppm)															
Calcium (Ca)	28	62	76	98	116	112	84	102	112						
Magnesium (Mg)	78	62	80	70	58	73	70	88	78						
Sodium (Na)	144	108	144	140	132	126	128	132	148						
Potassium (K)	2.5	1.1	2.0	2.2	1.9	2.0	1.9	1.5	4.6						
Ammonia (NH_4)	0	0	1.5	0.12	0	0.22	0.49	0.41	0.36						
ANIONS (ppm)															
Hydroxide (OH)	0	0	0	0	0	0	0	0	0						
Carbonate (CO_3)	24	12	18	12	12	24	0	0	0						
Bicarbonate (HCO_3)	311	354	458	500	476	482	500	591	604						
Sulfate (SO_4)	375	300	380	382	382	382	321	358	368						
Chloride (Cl)	20	15	20	20	20	25	10	13	12						
Nitrate (NO_3)	1.9	0.84	1.9	3.4	2.1	2.8	2.4	3.5	3.0						
Boron (B)	0.13	0.13	0.08	0.08	0.18	0.20	0.37	0.33	0.27						
Silica (SiO_2)	18	18	18	31	19	19	17	17	19						
Iron (Fe)	0.02	0	0.16	0.31	2.7	1.6	6.4	0.41	0.15						
Manganese (Mn)	0	0	0	0	0	0	0	0	0						
NUTRIENTS (ppm)															
Ortho Phosphate (PO_4)	0.05	0	0.03	0.11	0.16	0.02	0.06	0	0.09						
Nitrite (N)	0.003	0.005	0	0.005	0	0.010	0	0.012	0.005						
Nitrate (N)	0.43	0.19	0.43	0.77	0.48	0.64	0.54	0.80	0.67						
Ammonia (N)	0	0	1.2	0.09	0	0.17	2.4	0.32	0.28						
MICROBIOLOGY															
Standard Plate Count/ml at 35°C	2200	520	69,000	360,000	26,000	130,000	25,000	63,000	28,000						
Coliform MPN/100 ml	390	24,000	2,400	2400	1500	750	2400	11,000	2400						
Fecal Coliform MPN/100 ml	43	< 3	< 3	93	7	9	240	< 3	210						
Fecal Streptococci MPN/100 ml	-	< 3	21	43	750	240	1500	240	2400						
Pathogens															
SEDIMENT ANALYSIS															
% Moisture								27.1							
% TKN								0.081	0.041						
% COD								1.3	0.54						
% Volatile Solids								2.3							

Table XI–33 (continued)

STATION : LWL

Note: ND = Not Detected

CONSTITUENTS	1974 Aug	1974 Sep	1974 Oct	1974 Nov	1974 Dec	1975 Jan	1975 Mar	1975 May	1975 Jul	1975 Sep	1975 Nov	1976 Jan	1976 Mar	1976 May	1976 Jul
Temperature (°F)			46°	45°		41°	46°	48°	53°						
pH			7.8	5.6		8.2	8.3	7.5	8.0						
Dissolved Oxygen (mg/l)			5.0	15	15	15	12	8.2	13.4						
Conductivity (μ ohms/cm)			1450	1600	1730	1700	1600	1680	1740						
Total Solids (ppm)			988	992		984	1028	1012	850						
Total Alkalinity ($CaCO_3$) (ppm)			450	465		445	450	490	490						
Total Hardness ($CaCO_3$) (ppm)			560	520		470	510	580	600						
CATIONS (ppm)															
Calcium (Ca)			98	108		10[illegible]	98	108	120						
Magnesium (Mg)			77	61		50	64	75	73						
Sodium (Na)			140	132		132	132	120	135						
Potassium (K)			1.5	1.4		1.5	1.5	1.1	3.2						
Ammonia (NH_4)			0.51	0.10		0.05	0.01	0.16	0.36						
ANIONS (ppm)															
Hydroxide (OH)			0	0		0	0	0	0						
Carbonate (CO_3)			24	6		18	24	0	0						
Bicarbonate (HCO_3)			500	488		506	500	598	598						
Sulfate (SO_4)			360	351		363	308	335	348						
Chloride (Cl)			15	15		25	10	10	10						
Nitrate (NO_3)			0.19	1.5		1.6	1.8	1.4	1.4						
Boron (B)			0.17	0.08		0.20	0.22	0.17	0.37						
Silica (SiO_2)			21	21		20	20	16	19						
Iron (Fe)			0.03	0.12		0.21	0.08	0.06	0.08						
Manganese (Mn)			0	0		0	0	0	0						
NUTRIENTS (ppm)															
Ortho Phosphate (PO_4)			0.03	0.07		0.14	0.11	1.9	0.08						
Nitrite (N)			0.005	0		0.005	0.020	0.005	0						
Nitrate (N)			0.19	0.34		0.36	0.41	0.32	0.32						
Ammonia (N)			0.39	0.08		0.04	0.01	0.12	0.28						
MICROBIOLOGY															
Standard Plate Count/ml at 35°C			2,300	39,000	110,000	97,000	200,000	520,000	4700						
Coliform MPN/100 ml			< 3	< 3	9	110	4	23	< 3						
Fecal Coliform MPN/100 ml			< 3	< 3	< 3	< 3	< 3	< 3	< 3						
Fecal Streptococci MPN/100 ml			< 3	< 3	< 3	15	200	< 3	< 3						
Pathogens															
SEDIMENT ANALYSIS															
% Moisture								22.7							
% TKN								0.037	0.035						
% COD								0.75	0.72						
% Volatile Solids								2.3							

Table XI–33 (continued)

STATION : UWL

Note: ND = Not Detected

CONSTITUENTS	1974 Aug	Sep	Oct	Nov	Dec	1975 Jan	Mar	May	Jul	Sep	Nov	1976 Jan	Mar	May	Jul
Temperature (°F)	57°	52°	48°	39°	-	36°	42°	49°	50°						
pH	7.0	8.9	7.8	5.6	8.1	8.2	8.2	7.8	8.2						
Dissolved Oxygen (mg/l)	8	12.0	10.0	15.0	15	15	11	8.8	15.0						
Conductivity (μ ohms/cm)	1375	1600	1375	2000	1600	160	1500	920	1580						
Total Solids (ppm)	796	800	908	936	904	960	984	924	820						
Total Alkalinity ($CaCO_3$)(ppm)	300	380	400	410	440	375	420	470	460						
Total Hardness ($CaCO_3$)(ppm)	400	450	510	520	545	485	495	580	550						
CATIONS (ppm)															
Calcium (Ca)	38	84	92	90	112	92	88	108	120						
Magnesium (Mg)	74	58	68	72	64	62	67	51	61						
Sodium (Na)	126	128	128	120	116	117	120	116	118						
Potassium (K)	1.5	0.9	1.5	1.5	1.4	1.7	1.5	1.4	2.7						
Ammonia (NH_4)	0	0	0.28	0	0	0.23	0.34	0.27	0.55						
ANIONS (ppm)															
Hydroxide (OH)	0	0	0	0	0	0	0	0	0						
Carbonate (CO_3)	60	12	18	24	0	12	24	0	0						
Bicarbonate (HCO_3)	244	439	451	451	537	433	464	573	561						
Sulfate (SO_4)	331	305	330	325	330	338	294	300	308						
Chloride (Cl)	20	10	70	15	15	25	10	9.0	9.8						
Nitrate (NO_3)	0.84	0.67	0.84	1.6	1.7	2.1	2.0	0.41	1.3						
Boron (B)	0.25	0.08	0.17	0.08	0.09	0.20	0.12	0.69	0.49						
Silica (SiO_2)	18	17	18	20	16	19	17	12	16						
Iron (Fe)	0.11	0	0.008	0.07	0.21	0.38	0.15	0.03	0.08						
Manganese (Mn)	0	0	0	0	0	0	0	0	0						
NUTRIENTS (ppm)															
Ortho Phosphate (PO_4)	0	0	0.02	0.06	0	0.07	0.04	0	0.02						
Nitrite (N)	0.015	0.005	0	0	0.005	0.014	0	0.008	0.005						
Nitrate (N)	0.19	0.15	0.19	0.36	0.39	0.48	0.46	0.41	0.30						
Ammonia (N)	0	0	-	0	0	0.18	0.26	0.21	0.43						
MICROBIOLOGY															
Standard Plate Count/ml at 35°C	340	110	7,700	1,000,000	1000,000	95,000	4,200	9,400	200,000						
Coliform MPN/100ml	150	23	23	75	240	75	4600	460	150						
Fecal Coliform MPN/100ml	93	< 3	< 3	< 3	< 3	4	240	< 3	75						
Fecal Streptococci MPN/100ml	-	< 3	< 3	9	93	43	43	< 3	1500						
Pathogens															
SEDIMENT ANALYSIS															
% Moisture								62.6							
% TKN								0.33	0.14						
% COD								5.1	2.81						
% Volatile Solids								5.1							

Table XI–34 WATER QUALITY SAMPLE ANALYSES FOR WHITE RIVER STATIONS

STATION : WR-1

Note: ND = Not Detected

CONSTITUENTS	1974					1975						1976			
	Aug	Sep	Oct	Nov	Dec	Jan	Mar	May	Jul	Sep	Nov	Jan	Mar	May	Jul
Temperature (°F)	61°	51°	43°	32°	32°	32°	36°	50°	61°						
pH	7.8	8.8	8.0	8.0	8.0	8.2	8.3	7.5	8.0						
Dissolved Oxygen (mg/l)	0	9.0	10.0	15	15	15	15	8.7	10.8						
Conductivity (μ ohms/cm)	750	820	720	1975	870	720	750	330	430						
Total Solids (ppm)	512	472	468	480	488	404	472	176	275						
Total Alkalinity ($CaCO_3$)(ppm)	210	200	185	100	195	145	160	95	130						
Total Hardness ($CaCO_3$)(ppm)	335	310	280	280	300	270	280	140	180						
CATIONS (ppm)															
Calcium (Ca)	116	88	76	72	74	72	80	40	52						
Magnesium (Mg)	11	22	22	24	28	22	19	9.7	12						
Sodium (Na)	59	49	54	57	57	39	47	11	22						
Potassium (K)	2.2	1.5	1.7	1.5	1.5	1.7	1.9	1.5	1.7						
Ammonia (NH_4)	0.18	0	0	0	0	0	0.01	0.08	0.33						
ANIONS (ppm)															
Hydroxide (OH)	0	0	0	0	0	0	0	0	0						
Carbonate (CO_3)	6	18	0	12	0	6.0	0	0	0						
Bicarbonate (HCO_3)	244	207	226	229	238	165	195	116	159						
Sulfate (SO_4)	153	153	162	150	157	140	138	39	58						
Chloride (Cl)	59	30	40	40	45	4	49	9.0	12						
Nitrate (NO_3)	0	0.04	0.03	0.93	1.2	1.2	0.22	1.3	0.23						
Boron (B)	0.13	0.08	0	0.17	0	0.20	0.18	0.90	0.24						
Silica (SiO_2)	16	14	15	16	15	18	17	13	15						
Iron (Fe)	0.16	0.35	0.36	0.66	0.07	0.19	0.94	11	1.4						
Manganese (Mn)	0	0	0	0	0	0	0	0	0						
NUTRIENTS (ppm)															
Ortho Phosphate (PO_4)	0	0	0	0	0.12	0	0.08	0	0.075						
Nitrite (N)	0	0.001	0	0.014	0.005	0.014	0	0	0						
Nitrate (N)	0	0.01	0.006	0.21	0.28	0.26	0.05	0.30	0.05						
Ammonia (N)	0.14	0	0	0	0	0	0.01	0.06	0.25						
MICROBIOLOGY															
Standard Plate Count/ml at 35°C	840	2000	6200	52,000	21,000	4000	22,000	220,000	15,000						
Coliform MPN/100 ml	750	460	11,000	240	11,000	1100	2400	>24,000	1500						
Fecal Coliform MPN/100 ml	460	< 3	< 3	2100	460	93	23	< 3	240						
Fecal Streptococci MPN/100 ml	-	< 3	9	23	240	43	240	< 3	240						
Pathogens									ND						
SEDIMENT ANALYSIS															
% Moisture								24.9							
% TKN								0.059	0.039						
% COD								0.92	1.06						
% Volatile Solids								1.9							

Table XI–34 (continued)

STATION : WR-2

Note: ND = Not Detected

CONSTITUENTS	1974 Aug	1974 Sep	1974 Oct	1974 Nov	1974 Dec	1975 Jan	1975 Mar	1975 May	1975 Jul	1975 Sep	1975 Nov	1976 Jan	1976 Mar	1976 May	1976 Jul
Temperature (°F)	59°	51°	43°	32°	32°	32°	36°	47°	59°						
pH	7.4	8.8	8.0	8.0	8.0	8.3	8.5	7.1	8.0						
Dissolved Oxygen (mg/l)	8	10.0	10.0	15.0	15.0	15.0	15.0	8.6	9.8						
Conductivity (μ ohms/cm)	675	740	700	1775	690	200	900	370	460						
Total Solids (ppm)	424	440	462	408	404	452	556	240	270						
Total Alkalinity ($CaCO_3$)(ppm)	160	180	150	140	140	180	210	118	150						
Total Hardness ($CaCO_3$)(ppm)	265	300	270	250	270	275	295	157	190						
CATIONS (ppm)															
Calcium (Ca)	74	88	74	68	74	72	84	42	52						
Magnesium (Mg)	19	22	21	19	21	23	21	12	15						
Sodium (Na)	35	35	35	34	35	57	71	16	29						
Potassium (K)	1.9	1.2	1.9	1.4	1.2	1.7	2.0	1.5	2.2						
Ammonia (NH_4)	0.18	0	0	0	0	0.10	0.12	0	0.35						
ANIONS (ppm)															
Hydroxide (OH)	0	0	0	0	0	0	0	0	0						
Carbonate (CO_3)	12	12	0	12	0	12	18	0	0						
Bicarbonate (HCO_3)	171	195	183	146	171	195	256	144	183						
Sulfate (SO_4)	143	130	147	135	135	153	165	39	66						
Chloride (Cl)	39	35	35	40	45	43	40	9.0	13						
Nitrate (NO_3)	0	0.18	0	0.18	1.1	1.3	0.27	1.3	0.13						
Boron (B)	0	0	0	0.17	0	0.20	0.26	1.6	0.29						
Silica (SiO_2)	15	14	16	16	16	18	16	12	15						
Iron (Fe)	0.31	0.49	0.44	0.36	0.05	0.31	2.2	12	1.3						
Manganese (Mn)	0	0	0	0	0	0	0	0	0						
NUTRIENTS (ppm)															
Ortho Phosphate (PO_4)	0	0	0.07	0	0.04	0	0.04	0	0.08						
Nitrite (N)	0	0.003	0	0	0.005	0.010	0	0.062	0						
Nitrate (N)	0	0.004	0	0.004	0126	0.29	0.06	0.30	0.13						
Ammonia (N)	0.14	0	0	0	0	0.08	0.09	0	0.27						
MICROBIOLOGY															
Standard Plate Count / ml at 35°C	990	1700	3700	54,000	6600	5400	-	34,000	110,000						
Coliform MPN / 100 ml	2400	> 24,000	4600	1500	1500	75	-	11,000	2400						
Fecal Coliform MPN / 100 ml	240	< 3	< 3	240	390	75	-	< 3	93						
Fecal Streptococci MPN / 100 ml	-	< 3	23	9	93	43	-	23	93						
Pathogens	-	ND	ND	ND	ND	ND	-	ND							
SEDIMENT ANALYSIS															
% Moisture								29.5							
% TKN								0.037	0.017						
% COD								0.61	0.47						
% Volatile Solids								1.8							

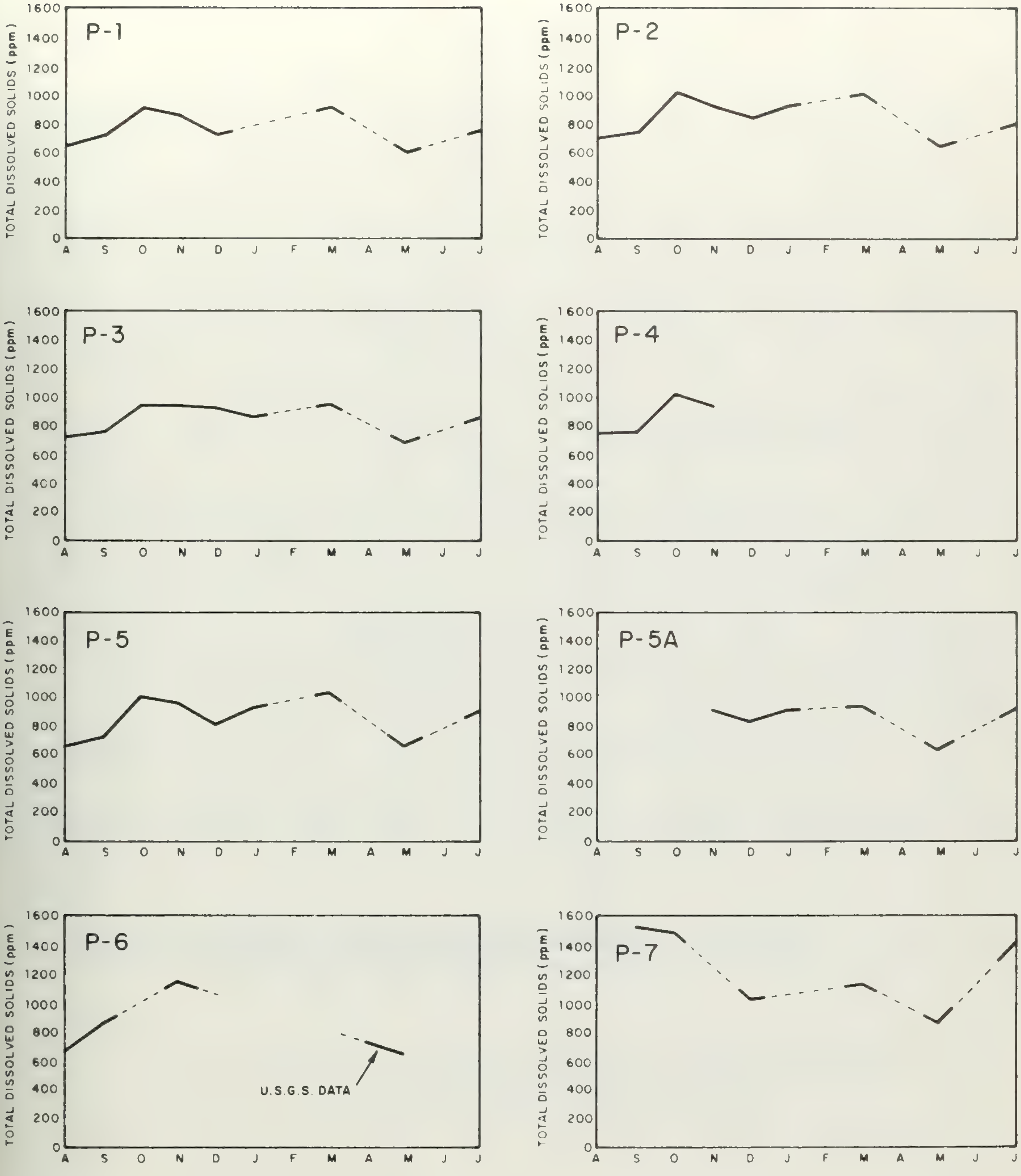

Figure XI-19 TOTAL DISSOLVED SOLIDS AT THE PICEANCE CREEK STATIONS, AUGUST 1974 TO JULY 1975

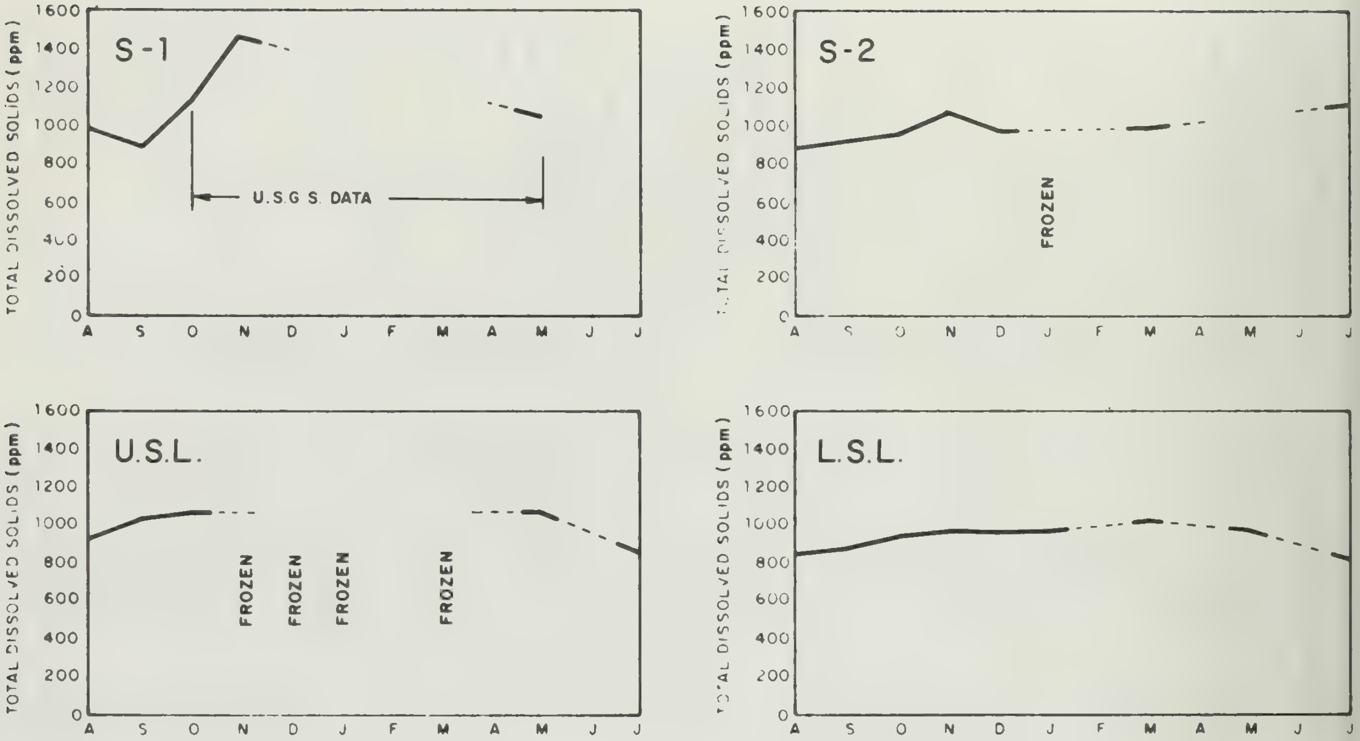

Figure XI–20 TOTAL DISSOLVED SOLIDS AT THE STEWART CREEK STATIONS, AUGUST 1974 TO JULY 1975

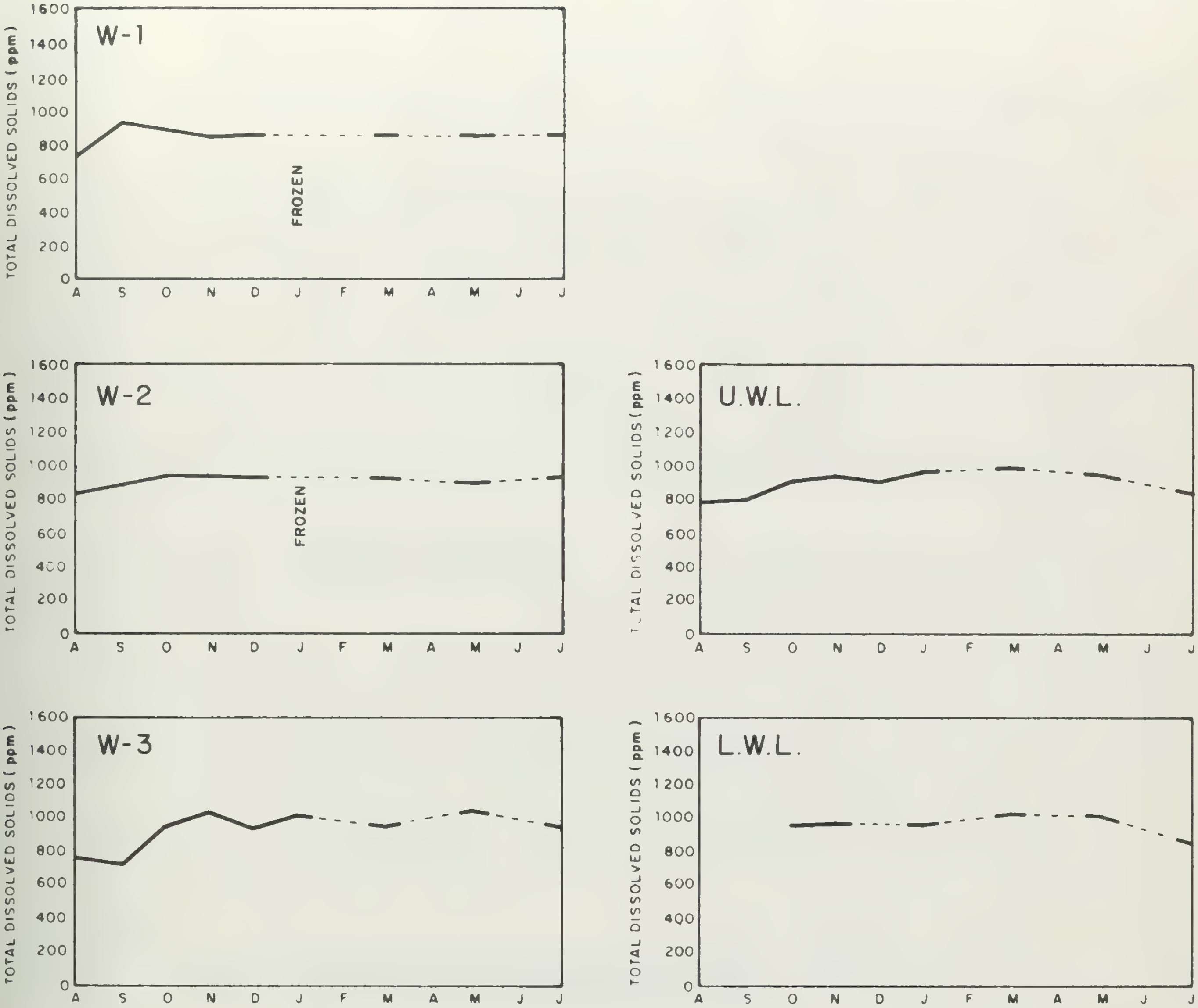

Figure XI–21 TOTAL DISSOLVED SOLIDS AT THE WILLOW CREEK STATIONS, AUGUST 1974 TO JULY 1975

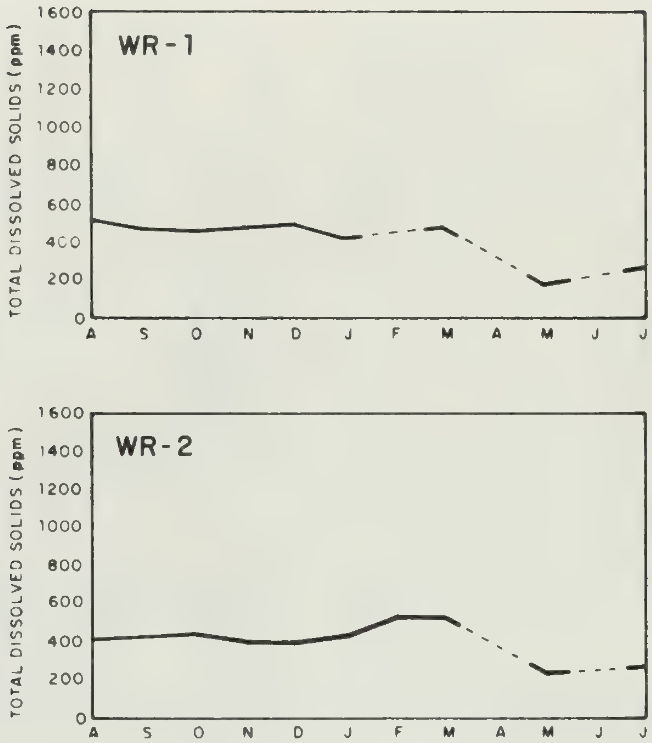

Figure XI-22 TOTAL DISSOLVED SOLIDS AT THE WHITE RIVER STATIONS, AUGUST 1974 TO JULY 1975

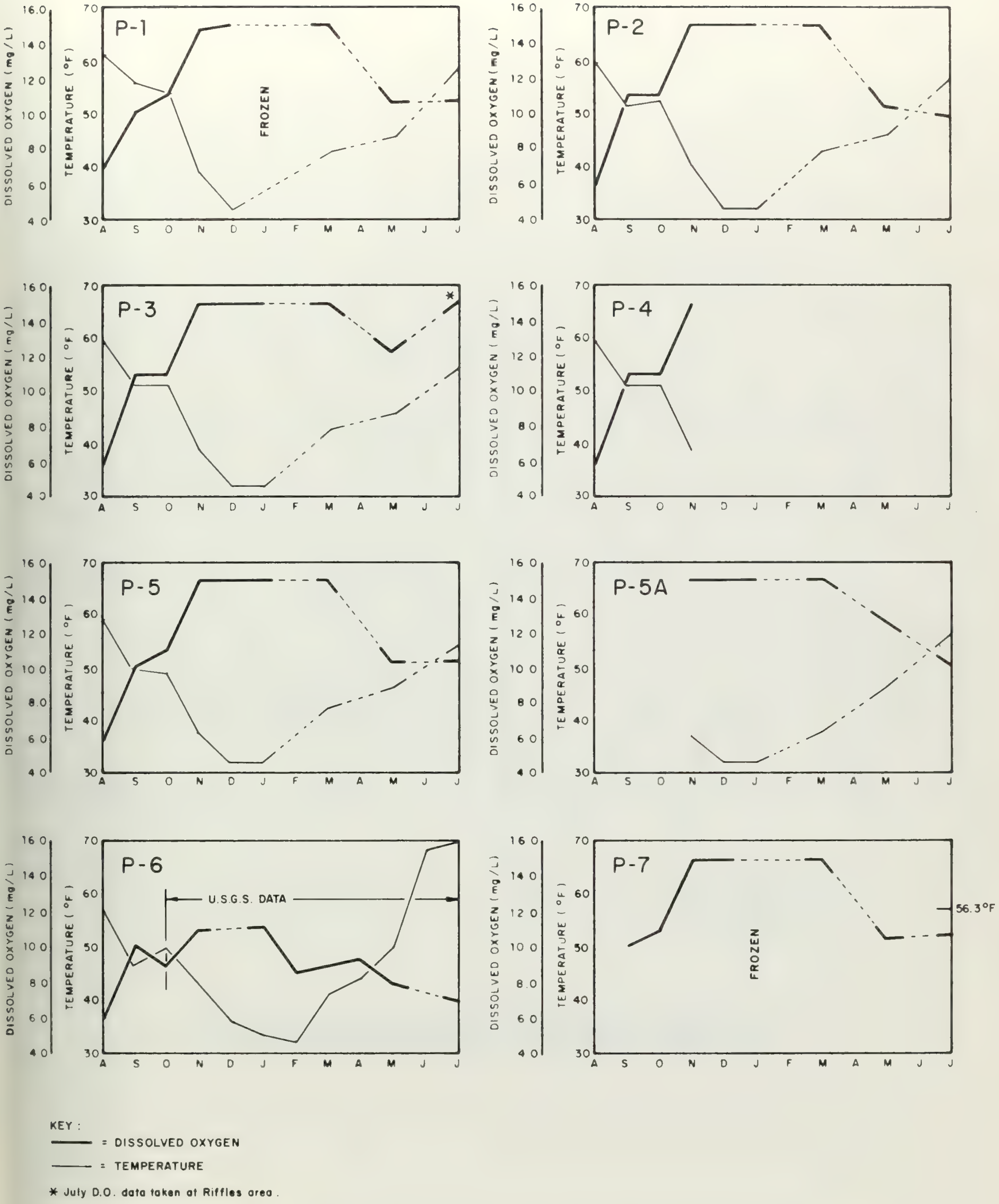

Figure XI-23 TEMPERATURE AND DISSOLVED OXYGEN AT THE PICEANCE CREEK STATIONS, AUGUST 1974 TO JULY 1975

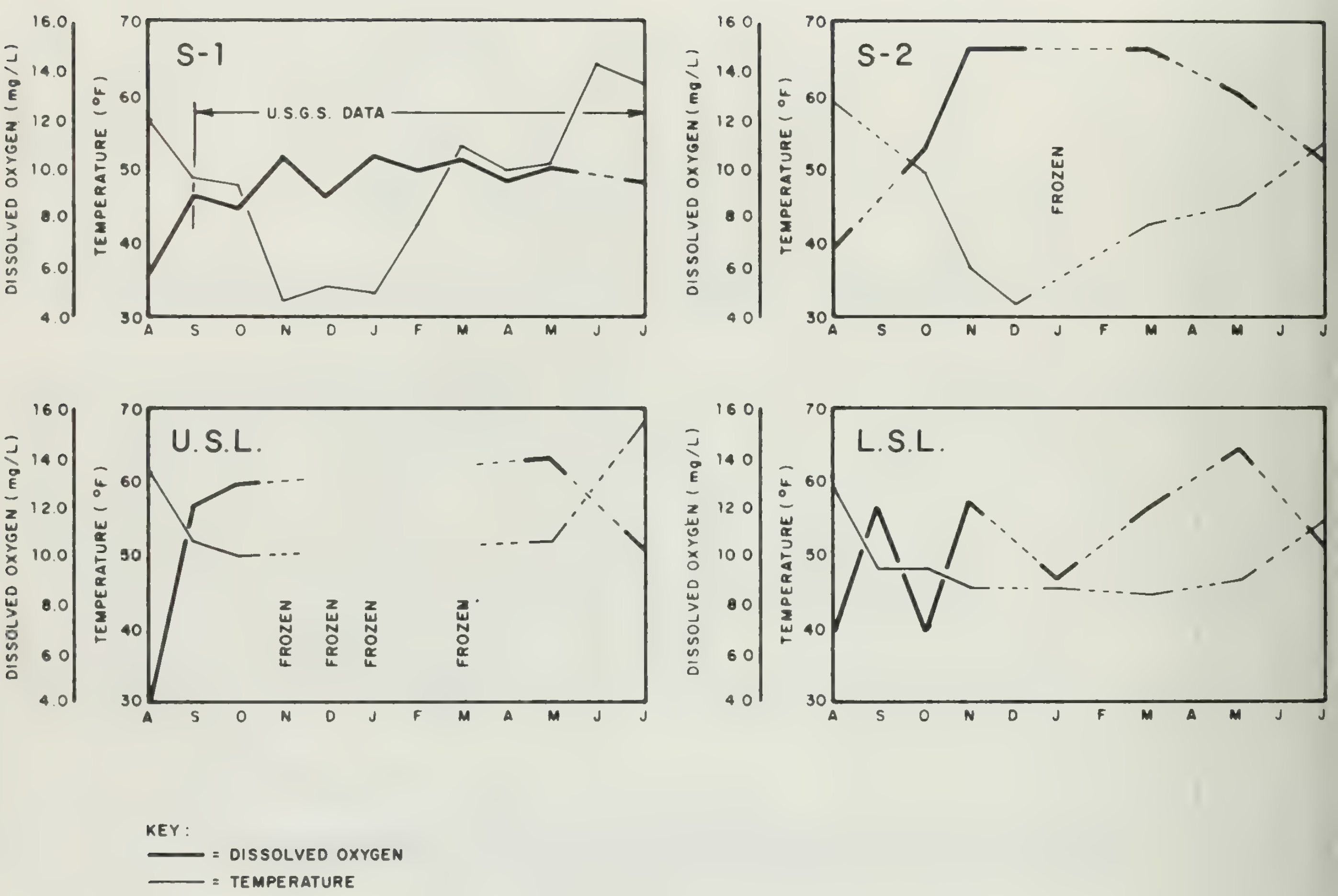

Figure XI-24 TEMPERATURE AND DISSOLVED OXYGEN AT THE STEWART CREEK STATIONS, AUGUST 1974 TO JULY 1975

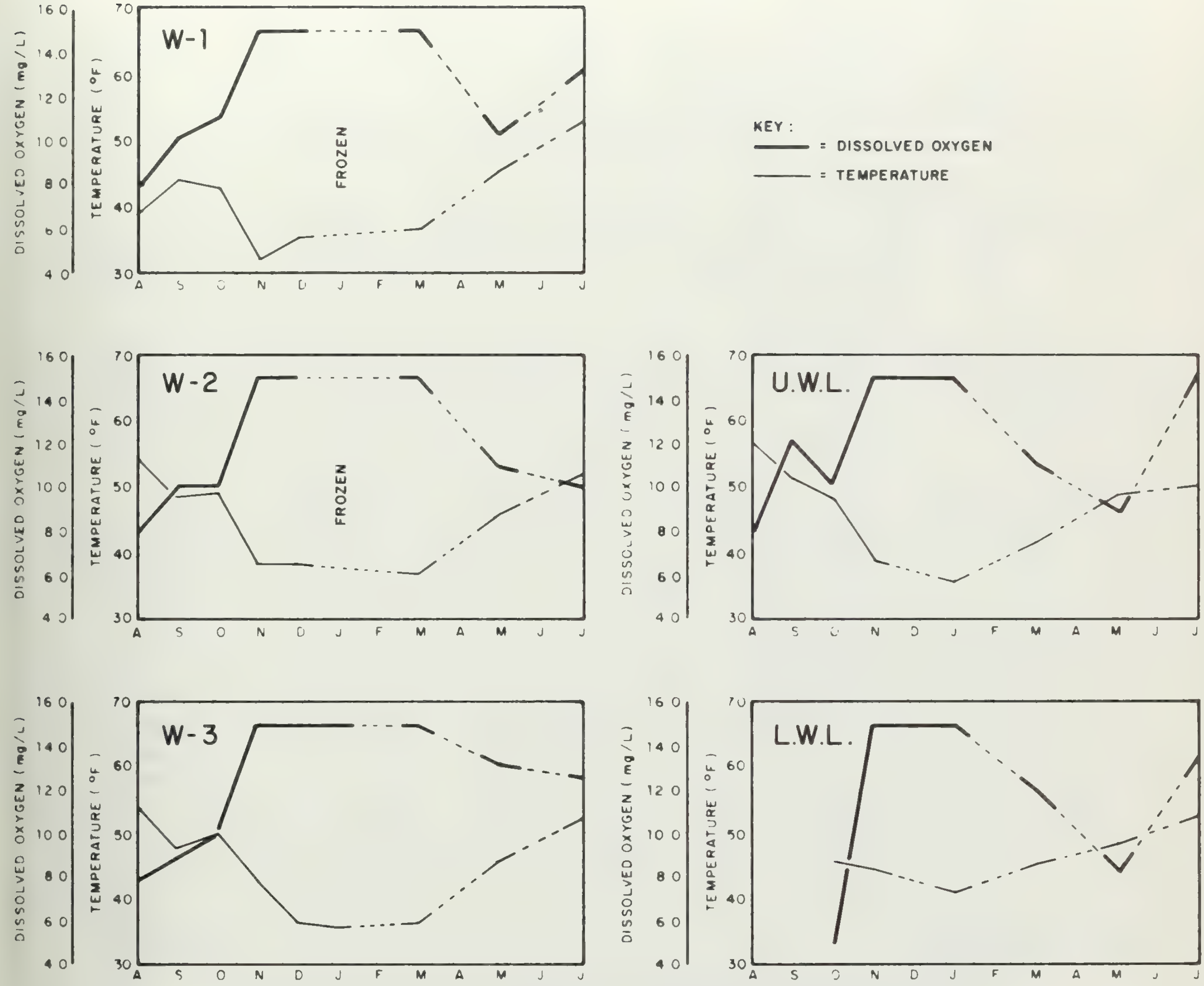

Figure XI-25 TEMPERATURE AND DISSOLVED OXYGEN AT THE WILLOW CREEK STATIONS, AUGUST 1974 TO JULY 1975

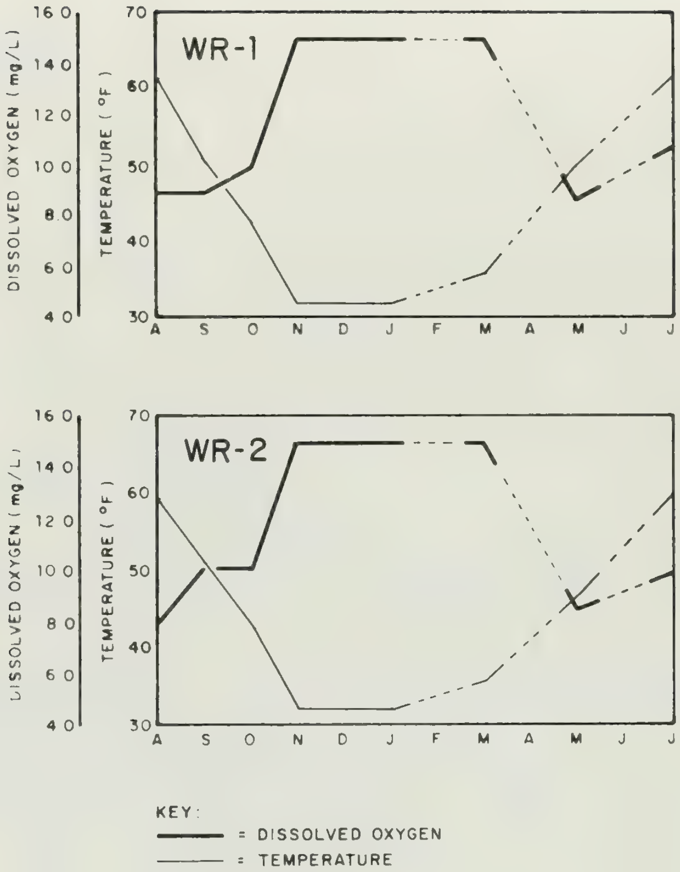

Figure XI-26 TEMPERATURE AND DISSOLVED OXYGEN AT THE WHITE RIVER STATIONS, AUGUST 1974 TO JULY 1975

C. Plant Communities and Dynamics

1. Introduction

Terrestrial vegetation studies on the Tract have been carried out during the past year. Twelve permanent study plots have been located on the Tract to gather data on structural, composition and functional aspects of vegetation. Studies include: identification of species, structural characteristics of plant communities, productivity, decomposition, phenology and the successional status of the vegetation.

Quadrats and belt transects are used for vegetative sampling. Tree measurements were made using point-quarter techniques. Productivity is estimated by repeated clipping of herbaceous vegetation and selected shrubs.

Decomposition studies are used to determine the rate at which plant litter decomposes in the four major vegetation types (described below). Nylon bags, filled with decomposition materials are buried, and recovered at specific times to be weighed and the rate of decomposition is measured by the loss of weight. Rate of litter fall is also measured.

Final mapping of the vegetation of the Tract as shown on Figure XI-27 was produced at a scale of 1:12,000 using a modification of Kuchler's comprehensive mapping techniques. In this technique, information which is portrayed on photographs is transferred to a base map.

The Tract lies in the pinyon-juniper ecosystem of the Intermountain Region. The variation in vegetation encountered within this broad ecosystem type in the western United States is extreme. The Tract and its surrounding area, however, encompass only a slight portion of this variation. A second level of division categorizes 14 terrestrial vegetation types as set forth in Table XI-35. The four major communities include: 1) pinyon-juniper woodland (Pinus edulis, Juniperus Osteosperma), 2) chained pinyon-juniper rangeland (plateau shrublands), 3) upland sagebrush (Artemisia tridentata), 4) bottomland sagebrush (Artemisia tridentata); and the additional types include 5) Douglas-fir forest (Pseudotsuga menziesii), 6) mixed mountain shrubland (Quercus gambelii, Amelanchier alnifolia, Cercocarpus montanus, Symphoricarpos oreophilus), 7) bunchgrass (Oryzopis hymenoides, Agropyron spicatum), 8) Marshlands (Typha latifolia, Phragmites communis), 9) Riparian (Carex spp.), 10) Great Basin wild rye (Elymus cinereus), 11) rabbitbrush (Chrysothamnus nauseosus) 12) greasewood (Sarcobatus vermiculatus), 13) agricultural meadows (Phleum pratense, Medicago sativa), and 14) annual weeds (Salsola kali, Lepidium montanum, Bromus tectorum).

The distribution of these types is mapped in Figure XI-27. Chained pinyon-juniper rangelands are the most extensive vegetation type on the Tract. Approximately 45 percent of the Tract was chained during a range improvement program undertaken in 1966 by the BLM. The remaining pinyon-

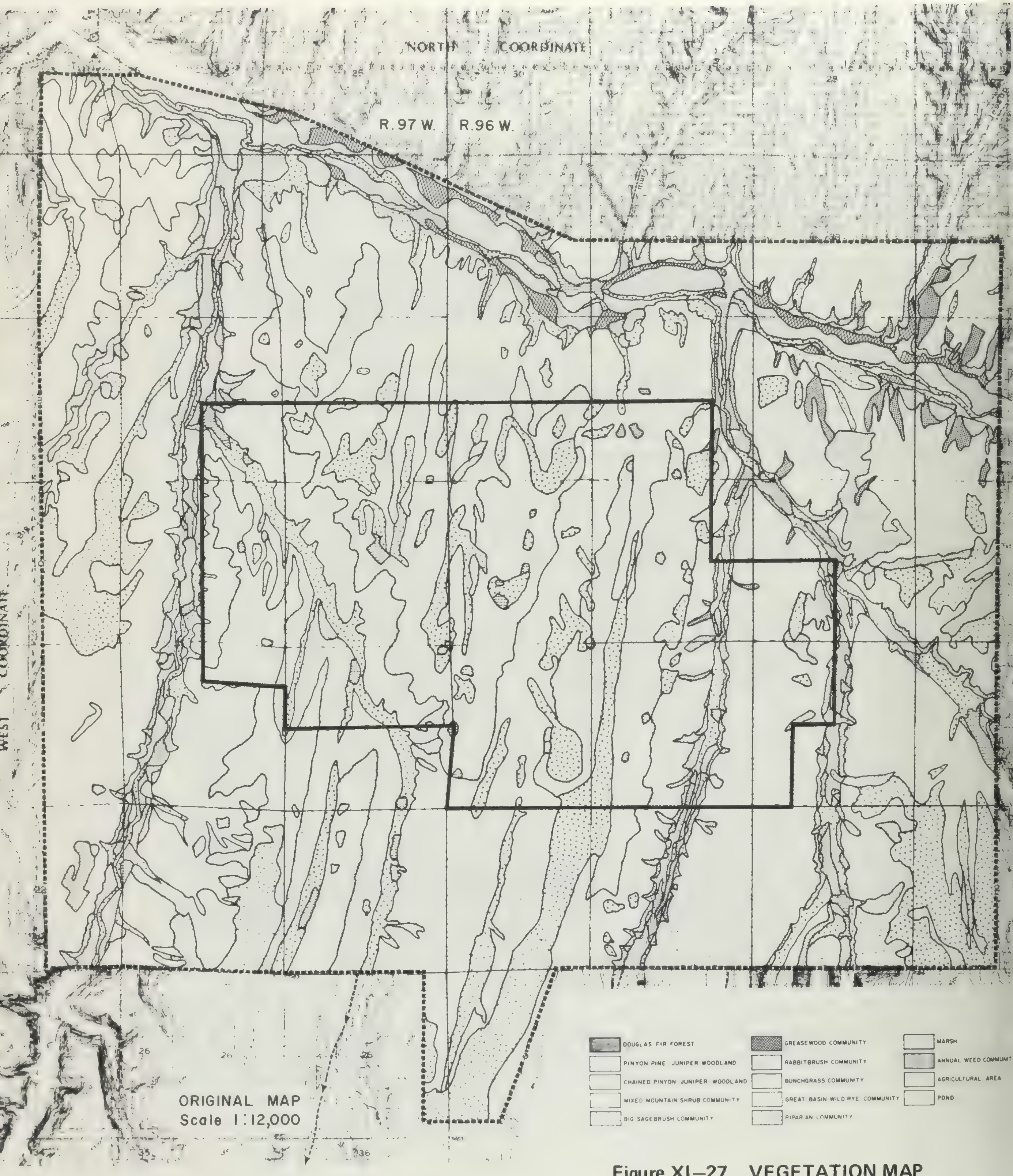

Figure XI–27 VEGETATION MAP
TRACT C-b

Table XI–35 COMMUNITY TYPES OF TRACT C-b

Vegetation Type	Dominant Species
Pinyon-Juniper Woodland	Pinyon pine Utah juniper Rocky Mountain juniper
Chained Pinyon-Juniper Rangeland	Big sagebrush Mountain mahogany Antelope bitterbrush
Bottomland Sagebrush	Big sagebrush Winterfat Rubber rabbitbrush
Upland Sagebrush	Big sagebrush
Douglas-fir Forest	Douglas-fir
Mixed Mountain Shrubland	Gambel's oak Serviceberry Mountain mahogany Snowberry Big sagebrush
Rabbitbrush	Rubber rabbitbrush
Greasewood	Greasewood
Bunchgrass	Indian ricegrass Blue-bunchwheatgrass Sulfur flower Sagewort Pasture sage
Marshlands	Cattail Common reed Sedge
Riparian	Sedges
Agricultural Meadows	Alfalfa Timothy Sedge
Annual Weeds	Russian thistle Pigweed Mountain peppergrass
Great Basin Wild Rye	Great Basin Wild Rye

juniper woodlands are generally restricted to the sides and bottoms of the more shallow draws and to the ridgetops bounded by steeper valleys.

Sagebrush-dominated communities occur on plateau sites and in the valley bottoms. Plateau sagebrush communities occur on ridgetops in large clearings in the original woodland. The bottomland communities occur on deep alluvial deposits in the gulches. The sage in these communities grows much larger and more dense than on the ridgetops.

Douglas-fir forest occurs in isolated areas on the north-facing slopes of small steep-sides gulches. The mixed mountain shrub communities are found infrequently on gentle north-facing slopes. Rabbitbrush communities occur on alluvial deposits in gulch bottoms. The formation of the rabbitbrush communities appear to be related to grazing practices in valley bottom communities and appear to be successional to the bottomland sagebrush stands. Greasewood stands occur locally on the toes of the alluvial fans, especially where high salt concentrations are found. Bunchgrass stands occur on south-facing slopes in the major gulches on the colluvium deposited from the sides of the gulches. Marshlands are found along the major creek drainages, principally Piceance Creek, and are adjacent to the agricultural meadows located on the deep alluvium of these larger valleys. The annual weed communities occur on randomly located disturbed sites throughout the region.

2. Regional Flora

The geographical distribution of the flora species of the Tract are summarized in Table XI-36. The flora of the Tract and its surrounding area is made up principally (approximately 78%) of species with characteristic North American distributions. Fifty-two percent of the species have temperate American western distributions. The flora contains Western species from two major floristic regions: the Rocky Mountain and the Intermountain West. Approximately 16 percent of the species in the area have been introduced primarily from European and Eurasian distributions. The flora of the area is listed in alphabetical order by common name, with the corresponding scientific name, in Table XI-37. Table XI-38 is a listing of life form abbreviations. Table XI-39 is an annotation of vascular flora, including an alphabetical list of species by scientific name. It indicates appropriate abbreviations of life forms, a statement of relative abundance, community affinity, a statement indicating the geographical distribution of the species, whether the species is native or introduced, a statement indicating if the species is rare or endangered (if applicable), botantical family and synonomy (if applicable).

3. Terrestrial Plant Communities

The various types of plant communities existing on and around the Tract were defined by studying a total of 28 sampling stands. These stands are listed in Table XI-40 and located in Figure XI-29. The

Table XI–36 SUMMARY OF GEOGRAPHICAL DISTRIBUTION OF THE SPECIES PRESENT IN THE FLORA OF TRACT C-b

Geographical Distribution	Number of Species	Percent of Flora
Circumpolar Distributions		
Arctic circumpolar (Ca)	4	2.3
Arctic-subarctic circumpolar (Cas)	3	1.7
Subarctic circumpolar (Cs)	1	0.6
Subarctic-temperate circumpolar (Cst)	2	1.1
Temperate circumpolar (Ct)	2	1.1
Subtotal	12	6.8
American Distributions		
Arctic American (Aa)	1	0.6
Arctic-subarctic America (Asa)	2	1.1
Subarctic American (As)	14	8.1
Western (Asw)	5	2.9
Subarctic-temperate Amer. (Ast)	6	3.5
Western (Astw)	10	5.8
Temperate American (At)	7	4.0
Western (Atw)	90	52.0
Subtotal	135	78.0
Other Distributions		
European (Ep)	12	7.0
Eurasian (Er)	12	7.0
African (Af)	1	0.6
Tropical American (Ta)	1	0.6
Subtotal	26	15.2
Total	173	100.0

Table XI–37 ALPHABETICAL LISTING OF COMMON NAMES FOR THE FLORA OF TRACT C-b

Common Name	Scientific Name
TREES, SHRUBS, AND VINES	
Antelope bitterbrush	Purshia tridentata
Big sagebrush	Artemisia tridentata
Blue clematis	Clematis columbiana
Box elder	Acer negundo
Chokecherry	Prunus virginiana var. melanocarpa
Currant	Ribes cereum
Douglas-fir	Pseudotsuga menziesii
Four-winged saltbush	Atriplex canescens
Gambel's oak	Quercus gambelii
Golden currant	Ribes aureum
Greasewood	Sarcobatus vermiculatus
Horsebrush	Tetradymia canescens
Mormon tea	Ephedra viridis
Mountain mahogany	Cercocarpus montanus
Narrow-leaf cottonwood	Populus angustifolia
Oregon grape	Mahonia repens
Pinyon pine	Pinus edulis
Prickly pear	Opuntia polyacantha
Rabbitbrush	Chrysothamnus viscidiflorus
Rock spirea	Holodiscus dumosus
Rocky Mountain juniper	Juniperus scopulorum
Rubber rabbitbrush	Chrysothamnus nauseosus
Serviceberry	Amelanchier alnifolia
Shadscale	Atriplex confertifolia
Siberian elm	Ulmus pumila
Silver buffaloberry	Shepherdia argentea
Skunkbush	Rhus trilobata

Table XI-37 ALPHABETICAL LISTING OF COMMON NAMES OF THE FLORA OF TRACT C-b (Continued)

Common Name	Scientific Name
Smooth currant	Ribes inerme
Snakeweed	Gutierrezia sarothrae
Snowberry	Symphoricarpos orephilus
Utah juniper	Juniperus osteosperma
Western virgin's-bower	Clematis ligusticifolia
Wild buckwheat	Eriogonum lonchophyllum
Wild hops	Humulus lupulus var. neomexicanus
Wild rose	Rosa woodsii
Willow	Salix sp.
Winter fat	Ceratoides lanata
HERBS	
Alfalfa	Medicago sativa
Alumroot	Heuchera parvifolia
Aster	Aster sp.
Balsam root	Balsamorhiza sagittata
Baltic rush	Juncus arcticus ssp. ater
Barnyard grass	Echinochloa crus-galli var. mitis
Bastard toadflax	Comandra pallida ssp. umbellata
Beard tongue	Penstemon sp.
Bee plant	Cleome serrulata
Biennial wormwood	Artemisia biennis
Blue-bunch wheatgrass	Agropyron spicatum
Blue grama	Bouteloua gracilis
Blue lettuce	Lactuca tatarica ssp. pulchella
Canada thistle	Cirsium arvense
Cattail	Typha latifolia
Cheatgrass	Bromus tectorum
Checker mallow	Sidalcea neomexicana
Cinquefoil	Potentilla gracilis
Clover	Trifolium gymnocarpon
Colorado bedstraw	Galium coloradoensis

Table XI–37 ALPHABETICAL LISTING OF COMMON NAMES OF THE FLORA OF TRACT C-b (Continued)

Common Name	Scientific Name
Common reed	Phragmites australis
Common sunflower	Helianthus annuus
Crested wheatgrass	Agropyron desertorum
Curly-cup gumweed	Grindelia squarrosa
Dandelion	Taraxacum officinale
Darnel	Lolium perenne
Death camas	Zigadenus venenosus var. gramineus
Dock	Rumex sp.
Double bladderpod	Physaria floribunda
Easter daisy	Townsendia hookeri, Townsendia incana
Eriogonum	Eriogonum flexum
Evening primrose	Calylophus hartwegii ssp. lavandulifolius Oenothera trichocalyx, Oenothera sp.
Evening star	Mentzelia rusbyi, Mentzelia sp.
Fairy candelabra	Androsace septentrionalis
False dandelion	Agoseris glauca
False flax	Camelina microcarpa
False gromwell	Onosmodium molle var. occidentalis
False Solomon's seal	Smilacina stellata
Fireweed	Epilobium sp.
Foxtail barley	Hordeum jubatum
Glaucous aster	Aster glaucodes
Goat's beard	Tragopogon dubius
Golden aster	Heterotheca villosa
Golden ragwort	Senecio multilobatus
Goldenrod	Solidago sparsiflora
Golden smoke	Corydalis aurea
Goldenweed	Haplopappus nuttallii
Goosefoot	Chenopodium fremontii, Chenopodium sp.
Great Basin wildrye	Elymus cinereus
Green sage	Artemisia dracunculus ssp. glauca
Gumbo lily	Oenothera caespitosa
Horsetail	Equisetum arvense

Table XI–37 ALPHABETICAL LISTING OF COMMON NAMES OF THE FLORA OF TRACT C-b (Continued)

Common Name	Scientific Name
Horseweed	Conyza canadensis
Indian paintbrush	Castilleja chromosa, Castilleja linariaefolia
Indian ricegrass	Oryzopsis hymenoides
Japanese brome	Bromus japonicus
Junegrass	Koeleria gracilis
Kentrophyta milk vetch	Astragalus kentrophyta
Kentucky bluegrass	Poa pratensis
Larkspur	Delphinium nelsoni
Little ricegrass	Oryzopsis micrantha
Long-leaved phlox	Phlox longifolia
Lupine	Lupinus argenteus, Lupinus sp.
Malcolmia	Malcolmia africana
Mariposa lily	Calochortus gunnisoni, Calochortus nuttallii
Marsh elder	Iva xanthifolia
Meadow goldenrod	Solidago canadensis
Miner's candle	Cryptantha sp.
Moss phlox	Phlox hoodii
Mountain peppergrass	Lepidium montanum
Much-branched gayophytum	Gayophytum ramosissimum
Mutton grass	Poa fendleriana
Needle-and-thread grass	Stipa comata
Nodding brome	Bromus porteri
Nodding eriogonum	Eriogonum cernuum
Nuttail's sunflower	Helianthus nuttallii
Orchard grass	Dactylis glomerata
Pasque flower	Pulsatilla patens ssp. multifida
Pasture sage	Artemisia frigida
Peppergrass	Lepidium perfoliatum
Phacelia	Phacelia idahoensis
Pigweed	Amaranthus retroflexus
Prairie bulrush	Scirpus paludosus
Prickly lettuce	Lactuca serriola

Table XI–37 ALPHABETICAL LISTING OF COMMON NAMES OF THE FLORA OF TRACT C-b (Continued)

Common Name	Scientific Name
Puccoon	Lithospermum sp.
Pussytoes	Antennaria rosea, Antennaria parvifolia
Rabbit's-foot grass	Polypogon mouspelliensis
Ragweed	Ambrosia artemisiifolia
Ragwort	Senecio eremophilus var. kingii
Red top	Agrostis gigantea
Rock cress	Arabis holboellii
Russian thistle	Salsola iberica
Sagewort	Artemisia ludoviciana
Sand dropseed	Sporobolus cryptandrus
Scarlet gilia	Ipomopsis aggretata
Scarlet globe mallow	Sphaeralcea coccinea
Scouring rush	Equisetum hyemale, Equisetum laevigatum
Seaside arrowgrass	Triglochin maritima
Sheep fescue	Festuca brachyphylla
Shore buttercup	Ranunculus cymbalaria
Short-rayed alkali aster	Brachyactis frondosa
Showy milkweed	Asclepias speciosa
Skeletonweed	Lygodesmia grandiflora
Slender wheatgrass	Agropyron trachycaulum
Sloughgrass	Beckmannia syzigachne
Smooth brome	Bromus inermis
Sow thistle	Sonchus arvensis
Speedwell	Veronica salina
Spreading dogbane	Apocynum androsaemifolium
Spurge	Chamaesyce sp., Euphorbia robusta
Squirreltail grass	Sitanion longifolium
Stickseed	Lappula redowskii
Stinging nettle	Urtica dioica
Sugarbowls	Clematis hirsutissima
Sulphur flower	Eriogonum umbellatum
Sweet vetch	Hedysarum boreale
Tansy mustard	Descurainia pinnata

Table XI-37 ALPHABETICAL LISTING OF COMMON NAMES OF THE FLORA OF TRACT C-b (Continued)

Common Name	Scientific Name
Tassel-flower brickellbrush	Brickellia grandiflora
Thistle	Cirsium sp.
Timothy	Phleum pratense
Tule	Scirpus lacustris ssp. validus
Tumble mustard	Sisymbrium altissimum
Twistflower	Streptanthus cordatus
Umbrellawort	Oxybaphus linearis
Utah daisy fleabane	Erigeron utahensis
Watercress	Rorippa nasturtium-aquaticum
Western wheatgrass	Agropyron smithii
White pigweed	Amaranthus albus
White sweet clover	Melilotus alba
Wild flax	Linum lewisii
Wild licorice	Glycyrrhiza lepidota
Winged eriogonum	Eriogonum alatum
Wing-fruited sand verbena	Tripterocalyx micranthus
Yarrow	Achillea lanulosa
Yellow evening primrose	Oenothera strigosa
Yellow sweet clover	Melilotus officinalis
Yucca	Yucca glauca

Table XI–38 ABBREVIATIONS OF LIFE FORMS OF PLANTS USED IN DESCRIBING THE FLORA OF TRACT C-b

Ph - Phanerophytes (perennating bud at least 0.25 m above soil surface)

- MM - Mega-, Mesophanerophytes (>8 m in height)
- M - Microphanerophytes (2-8 m in height)
- N - Nanophanerophytes (0.25-2.0 m in height)

(suffix "v" with any of the above symbols indicates a vine)

CH - Chamaephytes (perennating bud between 0 and 0.25 m above soil surface)

- CHP - passive chamaephytes
- Chcp- cushion plants

H - Hemicryptophytes (perennating bud in soil surface)

- Hp - Proto-hemicryptophytes without runners (plant leafy throughout)
- Hs - Semirosette without runners (plant with large basal leaves and smaller cauline leaves)
- Hr - Rosette without runners (plant with well-developed basal leaves and no cauline leaves)
- Hpr - Proto-hemicryptophytes with runners
- Hsr - Semirosette with runners
- Hrr - Rosette with runners

(runner is here used for either hypogeal or epigeal shoot)

Cr - Cryptophytes (perennating buds covered by soil or water)

- G - Geophytes (perennating buds covered by soil)
  - Grh - Rhizome
  - Gst - Stem-tuber
  - Grt - Root-tuber
  - Gb - Bulb
  - Gr - Root-bud
  - Gp - Root-parasite
- HH - Helo-, hydrophytes (perennating buds covered by water)

Th - Therophytes (annual plants, perennating buds contained in seed)

S - Stem succulents (stems enlarged; serve as water storage organ)

Table XI–39 ANNOTATED VASCULAR FLORA OF TRACT C-b

TREES, SHRUBS, AND VINES

Acer negundo L. Box Elder. (MM). Rare on Tract C-b; moist gulches along intermittent streams (Cottonwood Gulch). Not a rare species in Colorado. At – native. Aceraceae.

Amelanchier alnifolia Nutt. Serviceberry. (M). Common; a dominant species in mixed mountain shrub communities. Asw – native. Rosaceae.

Artemisia tridentata Nutt. Big Sagebrush. (M). Abundant; valley floors, ridges, and slopes over most of the tract. A secondary dominant in mixed mountain shrub communities and a dominant in sagebrush communities. Atw – native. Compositae.

Atriplex canescens (Pursh) Nutt. Four-winged Saltbush. (N). Scattered; dry colluvial slopes. On C-b usually found in Indian ricegrass communities. Atw – native. Chenopodiaceae.

Atriplex confertifolia (Torr. et Fremont) S. Wats. Shadscale. (N). Scattered; dry colluvial slopes and Indian ricegrass communities. Atw – native. Chenopodiaceae.

Ceratoides lanata (Pursh) J.T. Howell. Winter Fat. (N). Frequent; occurs as a secondary dominant with big sagebrush in valley sagebrush communities; uncommon elsewhere. Atw – native. Chenopodiaceae. (Syn. × Eurotia lanata [Pursh] Moquin).

Cercocarpus montanus Raf. Mountain Mahogany. (M). Common; a dominant species in mixed mountain shrub communities and a component of the shrub stratum in pinyon-juniper woodlands. Atw – native. Rosaceae.

Chrysothamnus nauseosus (Pall.) Britt. in Britt. et Brown. Rubber Rabbitbrush. (N). Common; a dominant species in heavily grazed valley communities; a secondary dominant on chained pinyon-juniper sites. Atw – native. Compositae.

Chrysothamnus viscidiflorus (Hook.) Nutt. Little Rabbitbrush. (N). Occasional; ridges and chained pinyon-juniper woodlands. Less common than rubber rabbitbrush. Atw – native. Compositae.

Table XI–39 ANNOTATED VASCULAR FLORA FOR TRACT C-b
(Continued)

Clematis ligusticifolia Nutt. ex T. et G. Western Virgin's-Bower. (Nv). Scattered; mixed mountain shrub communities and moist gulches. Atw – native. Ranunculaceae.

Clematis columbiana (Nutt.) T. et G. Blue Clematis. (Nv). Rare; sheltered gulches and steep forested north-facing slopes. Usually found on sites occupied by douglas-fir. Atw – native. Ranunculaceae.

Ephedra viridis Coville. Mormon Tea. (M). Scattered; sandstone outcrops and cliff tops. Atw – native. Ephedraceae.

(?) Eriogonum lonchophyllum T. et G. Wild Buckwheat. (N or Ch). Frequent; dry colluvial slopes and Indian ricegrass communities. Atw – native. Polygonaceae.

Eurotia lanata (Pursh) Moquin. See Ceratoides lanata.
Gutierrezia saro
Gutierrezia sarothrae (Pursh) Britt. et Rusby. Snakeweed. (Ch). Frequent; ridgetops and in chained pinyon-juniper woodlands. Atw – native. Compositae.

Holodiscus dumosus (Nutt.) Heller. Rock Spirea. (N). Very scattered; heads of draws and gulches, also along sheltered cliff bases on colluvial deposits. Atw – native. Rosaceae.

Humulus lupulus L. var. neomexicanus A. Nels. et Cockerell. Wild Hops. (Grh). Scattered; along permanent water courses (Piceance Creek) and irrigation ditches. Cst – native. Moraceae.

Juniperus osteosperma (Torr.) Little. Utah Juniper. (MM). Abundant; codominant species with pinyon pine in pinyon-juniper woodlands. More common than Rocky Mountain Juniper. Atw – native. Cupressaceae.

Juniperus scopulorum Sarg. Rocky Mountain Juniper. (MM). Relatively common; occurs as a secondary dominant with pinyon pine and Utah Juniper in pinyon-juniper woodlands. Atw – native. Cupressaceae.

Mahonia repens (Lindl.) G. Don. Oregon Grape. (Ch). Frequent; pinyon-juniper woodlands and mixed mountain shrub communities. Astw – native. Berberidaceae.

Table XI-39 ANNOTATED VASCULAR FLORA FOR TRACT C-b
(Continued)

Opuntia polyacantha Haw. Prickly Pear. (S). Common; throughout the tract in all communities. May reach greater density in overgrazed areas. Atw – native. Cactaceae.

Pinus edulis Engelm. Pinyon Pine. (MM). Abundant; dominant species in pinyon-juniper woodlands. Atw – native. Pinaceae.

Populus angustifolia James. Narrow-leaf Cottonwood. (MM). Rare; on Tract C-b restricted to Cottonwood Gulch. Not a rare species in Colorado, but rather one of the most widespread streamside cottonwood species. Atw – native. Salicaceae.

Prunus virginiana L. var. melanocarpa (A. Nels.) Sarg. Chokecherry. (M). Occasional; mixed mountain shrub communities and moist draws. Ast – native. Rosaceae.

Pseudotsuga menziesii (Mirbel) Franco. Douglas-Fir. (MM). Scattered; restricted to narrow draws with sheltered north- and northeast-facing exposures. The largest tree species in the area. Astw – native. Pinaceae.

Purshia tridentata (Pursh) DC. Antelope Bitterbrush. (N). Common; mixed mountain shrub communities, shrub layer of pinyon-juniper woodlands, and chained pinyon-juniper woodlands. Atw – native. Rosaceae.

Quercus gambelii Nutt. Gambel's Oak. (M). Frequent; mixed mountain shrub communities and heads of draws. Atw – native. Fagaceae.

Rhus trilobata Nutt. ex T. et G. Skunkbush. (N). Scattered; mixed mountain shrub communities. Atw – native. Anacardiaceae.

Ribes aureum Pursh. Golden Currant. (N). Scattered; along intermittent streams, draws, and gulches. Atw – native. Grossulariaceae.

Ribes cereum Dougl. Currant. (N). Scattered; along intermittent streams, draws, and gulches. Atw – native. Grossulariaceae.

Ribes inerme Rydb. Smooth Currant. (N). Scattered; along Piceance Creek and irrigation ditches. Astw – native. Grossulariaceae.

Table XI–39 ANNOTATED VASCULAR FLORA FOR TRACT C-b
(Continued)

Rosa woodsii Lindl. Wild Rose. (N). Occasional; draws, gulches, and intermittent streams. Asw – native. Rosaceae.

Salix sp. Willow. Salicaceae.

Sarcobatus vermiculatus (Hood.) Torr. Greasewood. (M). Frequent; dense stands present on alluvial fans on the north side of Piceance Creek. Atw – native. Chenopodiaceae.

Shepherdia argentea (Pursh) Nutt. Silver Buffaloberry. (N). Rare; deep gulches along intermittent streams (Sorghum Gulch). Not a rare species in Colorado, but very restricted on C-b. Atw – native. Eleagnaceae.

Symphoricarpos orephilus A. Gray. Snowberry. (N). Common; mixed mountain shrub communities, and as an understory component in pinyon-juniper woodlands. Atw – native. Caprifoliaceae.

Tetradymia canescens DC. Horsebrush. (N). Scattered; ridgetop sagebrush communities and chained pinyon-juniper woodlands. More common at higher elevations. Atw – native. Compositae.

Ulmus pumila L. Siberian Elm. (N). Rare; an introduced species much planted for shade. Only one small plant has been noted; an escapee from cultivation. Er – introduced. Ulmaceae.

HERBS

Achillea lanulosa Nutt. Yarrow. (Hsr). As – native. Compositae.

Agoseris glauca (Pursh) Raf. False Dandelion. (Hr). Relatively common; conspicuous in spring in pinyon-juniper woodlands. Atw – native. Compositae.

Agropyron smithii Rydb. Western Wheatgrass. (Grh). Relatively common; sagebrush communities and chained pinyon-juniper woodlands. Atw – native. Gramineae.

Agropyron desertorum (Fisch.) Schult. Crested Wheatgrass. (Hs). Relatively common; chained pinyon-juniper woodlands and other disturbed sites. This species is commonly seeded for range improvement. Er – introduced. Gramineae.

Table XI–39 ANNOTATED VASCULAR FLORA FOR TRACT C-b
(Continued)

Agropyron spicatum (Pursh) Scribn. et Smith. Bluebunch Wheatgrass. (Hs). Frequent; dry colluvial slopes, Indian ricegrass communities, and pinyon-juniper woodlands. Atw – native. Gramineae.

(?) Agropyron trachycaulum (Link) Malte. Slender Wheatgrass. (Hs). As – native. Gramineae.

Agrostis gigantea Roth. Red Top. (Hsr). Frequent; irrigated pastures, along irrigation ditches and streams. Cs – native Gramineae.

Amaranthus albus L. White Pigweed. (Th). Common; roadsides and disturbed sites. Atw – native. Amaranthaceae.

Amaranthus retroflexus L. Pigweed. (Th). Occasional; disturbed sites in all communities. Ta – introduced. Amaranthaceae.

Ambrosia artemisiifolia L. Ragweed. (Th). Frequent; roadsides, along streams, and on disturbed sites. At – native. Compositae.

Androsace septentrionalis L. Fairy Candelabra. (Th or short-lived Hr). Frequent; open slopes, sagebrush communities. Blooms in early spring. Ca – native. Primulaceae.

Anemone patens L. See Pulsatilla patens ssp. multifida.

Antennaria parvifolia Nutt. Pussytoes. (Chp). Frequent; pinyon-juniper and chained pinyon-juniper woodlands. As – native. Compositae.

Antennaria rosea Greene. Pussytoes. (Chp). Frequent; pinyon-juniper and chained pinyon-juniper woodlands. As – native. Compositae.

Apocynum androsaemifolium L. Spreading Dogbane. (Hp). Scattered; along intermittent streams in gulches and draws. As – native. Apocynaceae.

(?) Arabis holboellii Hornem. Rock Cress. (Hs). Scattered; pinyon-juniper woodlands. Flowering in early May. As – native. Cruciferae.

Artemisia biennis Willd. Biennial Wormwood. (Hs). Occasional; sandy intermittent stream sides and dry channels. At – native. Compositae.

Table XI–39 ANNOTATED VASCULAR FLORA FOR TRACT C-b
(Continued)

Artemisia dracunculus L. ssp. glauca (Pallas) Hall et Clements. Green Sage. (Hs). Frequent; dry colluvial slopes and Indian ricegrass communities. Atw – native. Compositae.

Artemisia frigida Willd. Pasture Sage. (Hp or Ch). Frequent; dry colluvial slopes and Indian ricegrass communities. Cas – native. Compositae.

Artemisia ludoviciana Nutt. Sagewort. (Ch). Frequent; dry colluvial slopes and Indian ricegrass communities. At – native. Compositae.

Asclepias speciosa Torr. Showy Milkweed. (Grh). Atw – native. Asclepiadaceae.

(?) Aster fendleri A. Gray. Aster. (Hp). Atw – native. Compositae.

Aster frondosus (Nutt.) T. et G. See Brachyactis frondosa.

(?) Aster glaucodes Blake. Glaucous Aster. (Hp). Atw – native. Compositae.

Astragalus kentrophyta A. Gray. Kentrophyta Milk Vetch. (Hp). Frequent; exposed soil on steep slopes, weathered sandstone and disturbed sites. Atw – native. Leguminosae.

Balsamorhiza sagitta (Pursh) Nutt. Balsam Root. (Hr). Frequent; pinyon-juniper woodlands. Astw – native. Compositae.

Beckmannia syzigachne (Steud.) Fernald. Sloughgrass. (Th). Scattered; along Piceance Creek and possibly other more permanent water sources. As – native. Gramineae.

Bouteloua gracilis (H.B.K.) Lag. Blue Grama. (Hsr). Relatively common; pinyon-juniper and chained pinyon-juniper woodlands. Atw – native. Gramineae.

(?) Brachyactis frondosa (Nutt.) A. Gray. Short-rayed Alkali Aster. (Th). Atw – native. Compositae. (Syn. × Aster frondosus).

Brickellia grandiflora (Hook.) Nutt. Tassel Flower Brickellbrush. (Hs). Scattered; heads of draws and on colluvial deposits in gulches. Atw – native. Compositae.

Table XI–39 ANNOTATED VASCULAR FLORA FOR TRACT C-b
(Continued)

(?) Bromus porteri (Coult.) Nash. Nodding Brome. (Hs). Scattered; along stream courses in dry gulches. Atw – native. Gramineae. (Syn. × Bromus anomalus Rupr. ex Fourn).

Bromus inermis Leyss. Smooth Brome. (Hsr). Scattered; along streams and irrigation ditches. Er – introduced. Gramineae.

Bromus japonicus Thunb. Japanese Brome. (Th). Scattered; chained pinyon-juniper woodlands and disturbed sites. Er – introduced. Gramineae.

Bromus tectorum L. Cheatgrass. (Th). Common; occurs in all communities, but is more frequent in sagebrush and valley floor communities. Ep – introduced. Gramineae.

Calochortus gunnisoni S. Wats. Mariposa Lily. (Gb). Rare; chained pinyon-juniper woodlands and ridgetop sagebrush communities. Atw – native. Liliaceae.

Calochortus nuttallii Torr. Mariposa Lily. (Gb). Frequent; ridgetop sagebrush communities. More common than the previous species. Atw – native. Liliaceae.

Calylophus hartwegii (Benth.) Raven ssp. lavandulifolius (T. et G.) Towner et Raven. Evening Primrose. (Hp). Occasional; chained pinyon-juniper woodlands. Atw – native. Onagraceae. (Syn. × Oenothera lavandulaefolia).

Camelina microcarpa Andrz. False Flax. (Th). Scattered; valley pastures and disturbed sites. Ep – introduced. Cruciferae.

(?) Castilleja chromosa A. Nels. Indian Paintbrush. (Gp). Occasional; ridgetop sagebrush communities and chained pinyon-juniper woodlands. Atw – native. Scrophulariaceae.

Castilleja linariaefolia Benth. in DC. Indian Paintbrush. (Gp). Frequent; ridgetop sagebrush communities and chained pinyon-juniper woodlands. Atw – native. Scrophulariaceae.

Chamaesyce sp. Spurge. Euphorbiaceae.

Chenopodium fremontii S. Wats. Goosefoot. (Th). Occasional; chained pinyon-juniper woodlands and disturbed sites. Atw – native. Chenopodiaceae.

Table XI-39 ANNOTATED VASCULAR FLORA FOR TRACT C-b
(Continued)

Chenopodium sp. Goosefoot. Chenopodiaceae.

Chrysopsis villosa (Pursh) Nutt. ex DC. See Heterotheca villosa.

Cirsium arvense (L.) Scop. Canada Thistle. (Gr). Er – introduced. Compositae.

Cirsium sp. Thistle. Compositae.

Clematis hirsutissima (Pursh) Sugarbowls. (Hp). Rare; mixed mountain shrub communities on north-facing slopes. Not a rare species in Colorado, but known from only one location on C-b (Grid W66, N64). Atw – native. Ranunculaceae.

Cleome serrulata (Pursh) Bee Plant. (Th). Common; roadsides, disturbed sites, and dry washes. Atw – native. Capparidaceae.

Comandra umbellata (L.) Nutt. ssp. pallida (A.DC.) Piehl. Bastard Toadflax. (Grh). Frequent; chained pinyon-juniper and ridgetop sagebrush communities. Ast – native. Santalaceae.

Conyza canadensis (L.) Cronquist. Horseweed. (Th). Scattered; disturbed sites, and roadsides. Ast – native. Compositae.

Corydalis aurea Willd. Golden Smoke. (Hp). Occasional; steep sandy slopes and dry washes. As – native. Fumariaceae.

Cryptantha sp. Miner's Candle. Boraginaceae.

Dactylis glomerata L. Orchard Grass. (Hs). Scattered; pastures and hay meadows. Er – introduced. Gramineae.

Delphinium nelsoni Greene. Larkspur. (Grt). Occasional; ridgetop sagebrush communities and chained pinyon-juniper woodlands. Astw – native. Ranunculaceae.

Descurainia pinnata (Walt.) Britt. Tansy Mustard. (Th). Common; disturbed sites in all communities. A highly variable species, with 7 ssp. present in Colorado. Ast – native. Cruciferae.

Echinochloa crus-galli (L.) Beauv. var. mitis (Pursh) Peterm. Barnyard Grass. (Th). Scattered; disturbed sites in pastures, meadows, roadsides, and along streams. Er – introduced. Gramineae.

Table XI–39 ANNOTATED VASCULAR FLORA FOR TRACT C-b
(Continued)

Elymus cinereus Scribn. et Merr. Great Basin Wildrye. (Hsr). Frequent; valley sagebrush communities and heads of draws. At one time this species was more widespread, but conversion of floodplains to irrigated hay meadows has reduced its abundance. Atw – native. Gramineae.

Epilobium sp. Fireweed. Onagraceae.

Equisetum arvense L. Horsetail. (Grh – life forms are usually not given for cryptogams). Occasional; along Piceance Creek and irrigation ditches. Ca – native. Equisetaceae.

(?) Equisetum hyemale L. Scouring Rush. (Grh – life forms are usually not given for cryptogams). Scattered; along Piceance Creek. Ast – native. Equisetaceae.

Equisetum kansanum Schaffner. See Equisetum laevigatum.

Equisetum laevigatum A. Br. Scouring Rush. (Grh – life forms are usually not given for cryptogams). Occasional; along Piceance Creek and other relatively permanent water bodies. Atw – native. Equisetaceae. (Syn. × Equisetum kansanum).

Erigeron utahensis A. Gray. Utah Daisy Fleabane. (Hp). Occasional; chained pinyon-juniper woodlands and ridgetop sagebrush communities. Atw – native. Compositae.

Eriogonum alatum Torr. Winged Eriogonum. (Hr). Occasional; pinyon-juniper woodlands and exposed outcrops. Atw – native. Polygonaceae.

Eriogonum crenuum Nutt. Nodding Eriogonum. (Th). Occasional; pastures, roadsides, and other disturbed sites. Astw – native. Polygonaceae.

(?) Eriogonum flexum M.E. Jones. Eriogonum. Scattered; disturbed sites and steep slopes. Atw – native. Polygonaceae.

Eriogonum umbellatum Torr. Sulphur Flower. (Hr). Scattered; mixed mountain shrub, more abundant on north-facing slopes. Atw – native. Polygonaceae.

Table XI-39 ANNOTATED VASCULAR FLORA FOR TRACT C-b
(Continued)

Euphorbia robusta (Engelm.) Small. Spurge. (Hp). Scattered; dry colluvial slopes and Indian ricegrass communities. Atw – native. Euphorbiaceae.

Festuca brachyphylla Schultes. Sheep Fescue. (Hs). Occasional; pinyon-juniper woodlands and chained pinyon-juniper woodlands. Er – introduced. Gramineae.

Galium coloradoensis W.F. Wright. Colorado Bedstraw. (Hp). Scattered; steep dry colluvial slopes and Indian ricegrass communities. Atw – native. Rubiaceae.

Gayophytum ramosissimum T. et G. Much-branched Gayophytum. (Th). Scattered; along Piceance Creek and other relatively permanent water bodies. Atw – native. Onagraceae.

Gilia aggregata (Pursh) Spreng. See Ipomopsis aggregata.

Glycyrrhiza lepidota (Pursh) Wild Licorice. (Hp). Frequent; along Piceance Creek and irrigation ditches. Atw – native. Leguminosae.

Grindelia squarrosa (Pursh) Dunal. Curly-cup Gumweed. (Hp). Frequent; roadsides and other disturbed sites. Atw – native. Compositae.

Haplopappus nuttallii T. et G. Goldenweed. (Hp). Occasional; pinyon-juniper and chained pinyon-juniper woodlands. Astw – native. Compositae.

Hedysarum boreale Nutt. Sweet Vetch. (Hp). Scattered; ridgetop sagebrush communities and chained pinyon-juniper woodlands. Asa – native. Leguminosae.

Helianthus annuus L. Common Sunflower. (Th). Frequent; roadsides and disturbed sites. Atw – native. Compositae.

Helianthus nuttallii T. et G. Nuttall's Sunflower. (Hp). Occasional; along Piceance Creek and irrigation ditches. Atw – native. Compositae.

Heterotheca villosa (Pursh) Shinners. Golden Aster. (Hp). Relatively common; present in most communities on C-b but is uncommon in valley sagebrush communities. Atw – native. Compositae. (Syn. × Chrysopsis villosa).

Table XI-39 ANNOTATED VASCULAR FLORA FOR TRACT C-b
(Continued)

Heuchera parvifolia Nutt. ex T. et G. Alumroot. (Hr). Occasional; mixed mountain shrub communities and draws and gulches. Astw – native. Saxifragaceae.

Hordeum jubatum L. Foxtail Barley. (Hs). Occasional; valley sagebrush communities and moist meadows. Asa – native. Gramineae.

Ipomopsis aggregata (Pursh) V. Grant. Scarlet Gilia. (Hs). Relatively common; roadsides, dry washes, and pinyon-juniper woodlands. Atw – native. Polemoniaceae. (Syn. × Gilia aggregata).

Iva xanthifolia Nutt. Marsh Elder. (Th). Common; along Piceance Creek and irrigation ditches. Atw – native. Compositae.

Juncus arcticus Willd. ssp. ater (Rydb.) Hulten. Baltic Rush. (Grh). Scattered; marshes and along Piceance Creek and irrigation ditches. As – native. Juncaceae. (Syn. × Juncus balticus).

Juncus balticus Willd. See Juncus arcticus ssp. ater.

Koeleria cristata (L.) Pers. See Koeleria gracilis.

Koeleria gracilis Pers. Junegrass. (Hs). Relatively common; ridgetop sagebrush communities and chained pinyon-juniper woodlands. Ct – native. Gramineae. (Syn. × Koeleria cristata).

Lactuca pulchella (Pursh) DC. See Lactuca tatarica ssp. pulchella.

Lactuca serriola L. Prickly Lettuce. (Th). Occasional; roadsides and disturbed sites. Ep – introduced. Compositae. (Syn. × Lactuca scariola).

Lactuca tatarica (L.) C.A. May ssp. pulchella (Pursh) Stebbins. Blue Lettuce. (Hs). Scattered; mixed mountain shrub communities and rarely along roadsides. As – native. Compositae. (Syn. × Lactuca pulchella).

Lappula redowskii (Hornem.) Greene. Stickseed. (Th). Relatively common; pastures, valley sagebrush communities, and chained pinyon-juniper woodlands. Asw – native. Boraginaceae.

Table XI–39 ANNOTATED VASCULAR FLORA FOR TRACT C-b
(Continued)

Lepidium montanum Nutt. Mountain Peppergrass. (Hs). Common; valley sagebrush communities, disturbed sites, and occasionally in mixed mountain shrub communities. Atw – native. Cruciferae.

Lepidium perfoliatum L. Peppergrass. (Th). Frequent; pastures and heavily grazed sites. Ep – introduced. Cruciferae.

Linum lewisii (Pursh) Wild Flax. (Hp). Frequent; dry colluvial slopes and Indian ricegrass communities. Aa – native. Linaceae.

Lithospermum sp. Puccoon. Boraginaceae.

Lolium perenne L. Darnel. (Hs). Relatively rare; disturbed sites. A species introduced in the area; possibly mixed with other grass seed. Ep – introduced. Gramineae.

(?) Lupinus argenteus (Pursh) Lupine. (Hp). Atw – native. Leguminosae.

Lupinus sp. Lupine. Leguminosae.

Lygodesmia grandiflora (Nutt.) T. et G. Skeletonweed. (Gr). Scattered; dry slopes and pinyon-juniper woodlands. Atw – native. Compositae.

Malcolmia africana (L.) R. Br. Malcolmia. (Th). Common; roadsides and disturbed sites, especially around farm buildings. Blooms in very early spring. Af – introduced. Cruciferae.

Medicago sativa L. Alfalfa. (Hp). Abundant; this species is planted as a hay crop in the meadows along Piceance Creek, Willow Creek, and Stewart Creek. Er – introduced. Leguminosae.

Melilotus alba Desr. White Sweet Clover. (Hs). Frequent; along streams and dry washes. Occasionally along roadsides. Ep – introduced. Leguminosae.

Melilotus officinalis (L.) Lam. Yellow Sweet Clover. (Hs). Frequent; along streams and dry washes, occasionally along roadsides. Ep – introduced. Leguminosae.

Mentzelia rusbyi Wooton. Evening Star. (Grt). Occasional; dry colluvial slopes and roadsides. Atw – native. Loasaceae. (Syn. × Mentzelia nuda var. rusbyi).

Table XI–39 ANNOTATED VASCULAR FLORA FOR TRACT C-b
(Continued)

Mentzelia sp. Evening Star. Loasaceae.

Mirabilis linearis (Pursh) Heimerl. See Oxybaphus linearis.

Nasturtium officinale R. Br. See Rorippa pasturtium-aquaticum.

Oenothera caespitosa Nutt. ex Fraser. Gumbo Lily. (Hr). Occasional; steep roadsides and disturbed sites. Atw – native. Onagraceae.

Oenothera lavandulaefolia T. et G. See Calylophus hartwegii ssp. lavandulifolius.

Oenothera sp. Evening Primrose. Onagraceae.

Oenothera strigosa (Rydb.) Mack et Bush. Yellow Evening Primrose. (Hs). Scattered; along Piceance Creek and other moist areas. At – native. Onagraceae.

Oenothera trichocalyx Nutt. ex T. et G. Evening Primrose. (Hs). Rare; dry washes and alluvial deposits. Atw – native. Onagraceae.

Onosmodium molle Michx. var occidentalis (Mack.) Johnston. False Gromwell. (Hs). Scattered; roadsides and dry slopes. At – native. Boraginaceae.

Oryzopsis hymenoides (R. et S.) Ricker. Indian Ricegrass. (Hs). Common; dry colluvial slopes and chained pinyon-juniper woodlands. Atw – native. Gramineae.

Oryzopsis micrantha (Trin. et Rupr.) Thurber. Little Ricegrass. (Hs). Scattered; pinyon-juniper woodlands and valley sagebrush communities Atw – native. Gramineae.

Oxybaphus linearis (Pursh) Robbins. Umbrellawort. (Hp). Scattered; sandy ridges and slopes. Atw – native. Nyctaginaceae. (Syn. × Mirabilis linearis).

Penstemon sp. Beard Tongue. Scrophularicaeae.

(?) Phacelia idahoensis Henderson. Phacelia. (Hp). Occasional; pinyon-juniper woodlands and roadsides. Atw – native. Hydrophyllaceae.

Table XI–39 ANNOTATED VASCULAR FLORA FOR TRACT C-b
(Continued)

Phleum pratense L. Timothy. (Hs). Frequent; hay meadows and pastures. Er – introduced. Gramineae.

(?) Phlox hoodii Rich. Moss Phlox. (Chcp). Common; pinyon-juniper woodlands, ridgetop sagebrush communities, and chained pinyon-juniper woodlands. Asw – native. Polemoniaceae.

Phlox longifolia Nutt. Long-leaved Phlox. (Hp). Frequent; ridgetop sagebrush communities and chained pinyon-juniper woodlands. Atw – native. Polemoniaceae.

Phragmites australis (Cav.) Trin. ex Steud. Common Reed. (Hsr). Common; marshes and along Piceance Creek. Restricted to wet environments. Cst – native. Gramineae. (Syn. × Phragmites communis).

Phragmites communis Trin. See Phragmites australis.

Physaria floribunda Rydb. Double Bladderpod. (Hr). Frequent; steep slopes, dry washes, and pinyon-juniper woodlands. Atw – native. Cruciferae.

Poa fendleriana (Steud.) Vasey. Muttongrass. (Hs). Scattered; ridgetop sagebrush communities and chained pinyon-juniper woodlands. Atw – native. Gramineae.

Poa pratensis L. Kentucky Bluegrass. (Grh). Frequent; meadows, pastures, and along streams and irrigation ditches. Cas – introduced. Gramineae.

Polypogon monspeliensis (L.) Desf. Rabbit's-foot Grass. (Th). Scattered; along streams and irrigation ditches. Ep – introduced. Gramineae.

(?) Potentilla gracilis Dougl. ex Hook. Cinquefoil. (Hs). Relatively rare; sheltered gulches along rocky intermittent streams. Asw – native. Rosaceae.

Pulsatilla patens (L.) Mill. ssp. multifida (Pritzel) Zamels. Pasque Flower. (Hs). Rare; north-facing mountain shrub communities. Not rare in Colorado, but very restricted on Tract C-b. Ranunculaceae.

Table XI–39 ANNOTATED VASCULAR FLORA FOR TRACT C-b
(Continued)

Ranunculus cymbalaria (Pursh) Shore Buttercup. (Hsr). Scattered; wet sandy and streamside deposits along Piceance Creek. Ca – native. Ranunculaceae.

Rorippa nasturtium-aquaticum (L.) Shinz et Thell. Watercress. (HH). Scattered; in streams and shallow water, Stewart Creek. Ep – introduced. Cruciferae. (Syn. × Nasturtium officinale).

Rumex sp. Dock. Polygonaceae.

Salsola iberica Sennen et Pau. Russian Thistle. (Th). Common; roadsides and disturbed sites. Er – introduced. Chenopodiaceae. (Syn. × Salsola kali var. tenuiflora).

Salsola kali L. var. tenuiflora Tausch. See Salsola iberica.

Scirpus lacustris L. ssp. validus (Vahl) Koyama. Tule. (Grh). Scattered; along Piceance Creek and other relatively permanent streams. As – native Cyperaceae. (Syn. × Scirpus validus).

Scirpus paludosus A. Nels. Prairie Bulrush. (Grh). Scattered; along Piceance Creek and other relatively permanent streams. Astw – native. Cyperaceae.

Scirpus validus Vahl. See Scirpus lacustris ssp. validus.

Senecio eremophilus Rydb. var. kingii (Rydb.) Greenm. Ragwort. (Hp). Occasional; chained pinyon-juniper woodlands. Atw – native. Compositae.

Senecio multilobatus T. et G. ex A. Gray. Golden Ragwort. (Grh). Occastional; pinyon-juniper and chained pinyon-juniper woodlands. Atw – native. Compositae.

Sidalcea neomexicana A. Gray. Checker Mallow. (Hp). Occasional; hay meadows and pastures along Piceance Creek. Atw – native. Malvaceae.

Sisymbrium altissimum L. Tumble Mustard. (Th). Relatively common; chained pinyon-juniper woodlands and disturbed sites. Ep – introduced. Cruciferae.

Sitanion hystrix (Nutt.) J.G. Smith. See Sitanion longifolium.

Table XI–39 ANNOTATED VASCULAR FLORA FOR TRACT C-b
(Continued)

Sitanion longifolium J.G. Smith. Squirreltail Grass. (Hs). Frequent; sagebrush communities and chained pinyon-juniper woodlands. Atw – native. Gramineae. (Syn. × Sitanion hystrix).

Smilacina stellata (L.) Desf. False Solomon's Seal. (Grh). Relatively rare; Douglas-fir forests. As – native. Liliaceae.

Solidago canadensis L. Meadow Goldenrod. (Hsr). Scattered; along Piceance Creek. Ast – native. Compositae.

(?) Solidago sparsiflora A. Gray. Goldenrod. (Hsr). Scattered; along intermittent streams in draws and gulches. Atw – native. Compositae.

(?) Sonchus arvensis L. Sow Thistle. (Hsr). Scattered; meadows and pastures along Piceance Creek. Ep – introduced. Compositae.

Sphaeralcea coccinea (Pursh) Rydb. Scarlet Globe Mallow. (Hp). Common; ridgetop sagebrush communities and chained pinyon-juniper woodlands. Atw – native. Malvaceae.

(?) Sporobolus cryptandrus (Torr.) A. Gray. Sand Dropseed. (Hsr). Scattered; roadsides and sandy alluvial deposits. At – native. Gramineae.

Stipa comata Trin. et Rupr. Needle-and-Thread Grass. (Hs). Frequent; sagebrush communities and chained pinyon-juniper woodlands. Astw – native. Gramineae.

Streptanthus cordatus Nutt. ex T. et G. Twistflower. (Hs). Scattered; pinyon-juniper woodlands and chained pinyon-juniper woodlands. Atw – native. Cruciferae.

Taraxacum officinale Web. in Wiggers. Dandelion. (Hr). Frequent; roadsides and disturbed sites. Er – introduced. Compositae.

(?) Townsendia hookeri Beaman. Easter Daisy. (Hr). Frequent; ridgetop sagebrush communities, pinyon-juniper and chained pinyon-juniper woodlands. Atw – native. Compositae.

Townsendia incana Nutt. Easter Daisy. (Hr). Scattered; ridgetop sagebrush communities and chained pinyon-juniper woodlands. Atw – native. Compositae.

Table XI–39 ANNOTATED VASCULAR FLORA FOR TRACT C-b
(Continued)

Tragopogon dubius Scop. Goat's Beard. (Hs). Occasional; ridgetop sagebrush communities and chained pinyon-juniper woodlands. Ep – introduced. Compositae.

Trifolium gymnocarpon Nutt. Clover. (Hs). Relatively rare; pinyon-juniper woodlands and mixed mountain shrub communities. Atw – native. Leguminosae.

Triglochin maritima L. Seaside Arrowgrass. (Hr). Relatively rare; marshes and moist meadows along Piceance Creek and other streams. Cas – native. Juncaginaceae.

Tripterocalyx micranthus (Torr.) Hook. Wing-fruited Sand Verbena. (Th). Rare; sandy alluvial deposits. Atw – native. Nyctaginaceae.

Typha latifolia L. Cattail. (HH). Frequent; marshes and streamsides. Restricted to wet environments. As – native. Typhaceae.

Urtica dioica L. Stinging Nettle. (Hpr). Scattered; moist meadows in draws and gulches. As – native. Urticaceae.

Veronica salina Schur. Speedwell. (Hp). Scattered; streamside sites along Piceance Creek. Ct – native. Scrophulariaceae.

Yucca glauca Nutt. Yucca. (Hr). Occasional; chained pinyon-juniper woodlands. Atw – native. Liliaceae.

Zigadenus venenosus S. Wats. var. gramineus (Rydb.) Walsh ex M.E. Peck. Death Camas. (Gb). Scattered; ridgetop sagebrush communities and chained pinyon-juniper woodlands. Atw – native. Liliaceae.

Table XI–39 ANNOTATED VASCULAR FLORA FOR TRACT C-b
(Continued)

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Table XI–40 VEGETATION SAMPLING STANDS

STAND NUMBER	STAND TYPE
1f & 1–0	Chained Pinyon-Juniper Rangeland (Experimental Site)
2f & 2–0	Chained Pinyon-Juniper Rangeland (Control Site)
3f & 3–0	Upland Sagebrush Community
4f & 4–0	Bottomland Sagebrush Community
5f & 5–0	Pinyon-Juniper Woodland (Experimental Site)
6f & 6–0	Pinyon-Juniper Woodland (Control Site)
7	Chained Pinyon-Juniper Rangeland
8	Upland Sagebrush Community
9	Pinyon-Juniper Woodland (East-facing Slope)
10	Chained Pinyon-Juniper Rangeland
11	Upland Sagebrush Community
12	Pinyon-Juniper Woodland
13	Pinyon-Juniper Woodland
14	Chained Pinyon-Juniper Rangeland
15	Upland Sagebrush Community
16	Bottomland Sagebrush Community
17	Rabbitbrush Community
18	Greasewood Community
19	Bottomland Sagebrush Community
20	Bunchgrass Community
21	Douglas-fir Forest
22	Annual Weed Community
23	Annual Weed Community
24	Annual Weed Community
25	Annual Weed Community
26	Annual Weed Community
27	Annual Weed Community
28	Annual Weed Community

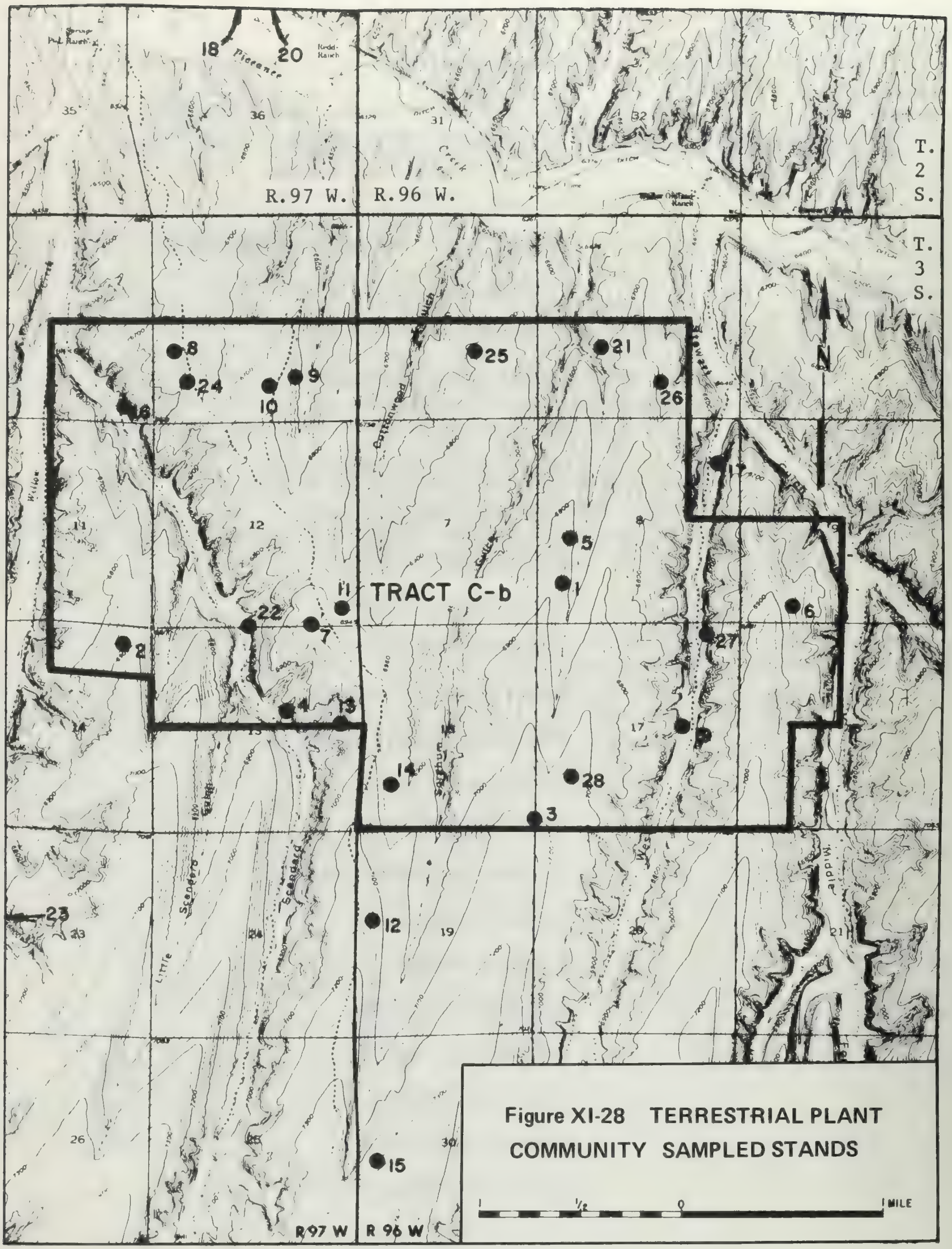


Figure XI-28 TERRESTRIAL PLANT COMMUNITY SAMPLED STANDS

percent ground cover and the frequency of herbaceous plants in each of the stands are given in Tables XI-41 and 42, respectively. Six of the stands (Stands 1 through 6) have been established as permanent plots for continuing studies. The productivity in these six stands is shown in Tables XI-43 and XI-44. Soil moisture contents in various locations on the Tract are shown in Table XI-45. The soil moisture sampling locations are shown in Figure XI-28. The plant communities defined from the stands study data are described below.

a. Pinyon-Juniper Woodlands

Pinyon-juniper woodlands are the most common and widespread vegetation type in this part of western Colorado. Total environmental characteristics favor the development of this type, but local soil, temperature, topographic and moisture conditions cause the mosaic of plant communities which occur in the region.

On Tract, this vegetation type occurs primarily on ridges and dry slopes and is mostly absent from alluvial deposits, talus slopes, and loamy soils of uplands. At one time, these woodlands covered most of the Tract, however Bureau of Land Management (BLM) chaining operations in 1966 removed approximately 2500 wooded acres within the Tract boundaries. Even though the total extent of the pinyon-juniper woodlands was reduced by more than 50%, it remains as one of the most common vegetation types on the Tract.

Structure and Composition. The tree layer of these woodlands is composed of varying amounts of pinyon pine, Utah juniper and Rocky Mountain juniper. Composition percentages vary from nearly pure stands of pinyon pine on broad ridges to steeply sloping sites where Utah juniper is the dominant species. All stands of this vegetation type, regardless of dominant species, tend to have limited canopy cover (32%) and low density (approximately 250 trees per hectare). The open canopy and wide spacing of individuals alter incoming solar radiation and seem to have a limited effect on understory development. Competition for water and nutrients tends to restrict the growth of shrubby and herbaceous plants.

Most of woodlands on the Tract have poorly developed herb and shrub layers. Shrub layer dominants vary from site to site. Big sagebrush usually occurs as the dominant species on ridgetop stands. Species more characteristic of mixed mountain shrublands (serviceberry, bitterbrush, and mountain mahogany) tend to dominate stands located on hillsides. In the open understory stands, shrub cover averages 4%, and total shrub density averages approximately 3200 shrubs per hectare (Tables XI-46, -47, -48 and -49). Herb cover in these same stands averages 15% with western wheatgrass, fleabane, sheep fescue, Junegrass, needle-and-thread grass, and Indian ricegrass occurring as dominant species (Tables XI-41 and -42, Stands 5-0, 5-f, 6-0, 6-f, 9 and 12).

Table XI–41 PERCENT GROUND COVER IN HERBACEOUS PLANT SAMPLING STANDS

STAND NO.

COVER CATEGORIES	1–0	1–f	2–0	2–f	3–0	3–f	4–0	4–f	5–0	5–f	6–0	6–f	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
Herbaceous Plants (% Cover)	15	23	26	44	30	44	17	14	7	9	11	22	42	46	22	38	63	20	26	36	43	27	51	43	17	29	13	46	82	38	30	50	34	4
Woody Plants 25 cm (% Cover)	1	–	–	–	1	1	2	2	–	–	–	–	1	2	<1	–	1	<1	–	2	4	3	2	2	4	–	1	2	–	–	–	–	–	–
Mosses (% Cover)	1	–	1	–	6	1	27	35	3	4	8	2	1	1	<1	–	1	<1	3	<1	2	1	5	–	–	–	10	–	–	–	–	–	–	–
Crustose Lichens (% Cover)	1	–	–	1	–	–	–	–	2	–	–	–	–	–	<1	–	–	<1	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–
Foliose & Fruticose Lichens (% Cover)	–	–	–	–	1	–	–	–	–	–	1	–	–	–	–	5	1	–	2	–	<1	–	–	–	–	–	4	–	–	–	–	–	–	–
Litter Cover (% Cover)	63	70	58	64	26	40	82	59	83	82	74	71	71	69	48	57	81	81	72	72	66	77	80	76	77	35	43	38	62	36	8	20	38	2
Bare Soil (% Cover)	31	26	24	23	51	19	7	17	15	14	23	29	26	31	33	41	19	18	22	28	32	20	13	21	18	42	3	26	14	38	70	36	56	94
Rock (% Cover)	3	2	2	3	–	–	–	–	2	2	–	–	1	2	18	3	1	<1	2	<1	<1	–	1	–	1	13	5	–	–	4	–	4	6	6

Table XI -42 PERCENT FREQUENCY OF HERBACEOUS PLANTS IN SAMPLED STANDS

STAND NO

SPECIES	1 0	1-f	2 0	2-f	3 0	3-f	4 0	4-f	5 0	5-f	6 0	6-f	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
Agoseris glauca	8	8		8	100	88				4	40	48		5		5	10				20													
Agropyron cristatum																								100										
Agropyron dasystachum																				25							30							
Agropyron desertorum	44	36	36	36					12	24			5	20	10	40	5						15	10										
Agropyron smithii	24	16	20	32	100	100	56	44		16	76	72	85	80	80	55	100	80	60	55	100	70	95	55	10	10		90	10	30	10	30	100	
Agropyron spicatum		4		4					8	4																								
Agropyron trachycaulum	4						4									10						10	5			10								
Allium acuminatum																					15													
Amaranthus albidus																												100	90				20	
Amaranthus graecizans																																		10
Androsace septentrionalis									4							10			35			5					60							
Antennaria parvifolia		8			20	28						8	15	25	5	15			10	20														
Antennaria rosea	20	12	4	12		4					48	40			5			5	25	20							50							
Arabis holboellii	16	8	32	12	84	80			12	28	24	36			5	-	10	20	15	15	20						50							
Artemisia dracunculus																							20			10							10	
Artemisia frigida								4																		40								
Artemisia ludoviciana	12	8										4	5						5			65	10		30									
Aster adscendens																			5															
Aster fendleri *																				40														
Astragalus ceramicus *			8	4								4		45	25		25		10							5								
Astragalus kentrophyta	8	28							-	4	32	36	5	25	10	–	5		5							10								
Astragalus pectinatus *						20							5	5		25					10													
Astragalus purshii	-	-	-		32	16					4		15					10			15										20			
Astragalus scopulorum			-	-		12															30													
Astragalus spatulatus					24	12				–						20				30														
Balsamorhiza sagittata																		20		5	15													
Bouteloua gracilis	4		12	12			12					4				10						20												
Brickellia grandiflora *																										60								
Bromus anomalus																											10							
Bromus inermis																							30											
Bromus japonicus																																70	30	40
Bromus marginatus *																			15															
Bromus tectorum	92	76	100	96		4	100	100	24	36	16		20	10	10			25	10	55		100	95	75	100	35		100	100	80	100	100	60	80
Calochortus nuttallii	8				100	100					8	16	5				15	15			35													
Calylophus hartwegii var lavandulaefolius												64																						
Carex sp	16							4								45		35																
Carex pensylvanica *	16	32	4		96	80			32	28	12	56	40	35	40		50	55		15	45						40			10				
Castilleja chromosa					12	64								5			65				55													
Castilleja linaraeifolia					24																													
Chaenactis douglasii	12	8								4						15					5		-								10	10	-	
Chamaesyce glyptosperma*																												10						
Chenopodium album	28	20	64	24			68	40	24	32	24	20	40		15		25	10		20	25		-			15	20	70			60		40	20
Chenopodium sp.															20							55	55	20	25					50				
Cirsium arvense																														10				
Cirsium sp.								4	4						10				5							15								
Cleome serrulata																							5											
Collinsia parviflora		12	8						40	60	12	8	15				5	10			85						20							
Collomia linearis																					40													
Comandra umbellata var pallida											12	60		5	35	20	5	10	10		30											10		
Crepis acuminatus										–			5	15	10		35	60	5	30	80													
Cruciferae (unknown)															5																			
Cryptantha sp	8	24							24	16			5			10	-		10	20													10	10
Cymopterus montanus *	12									–	28	12																						
Delphinium nelsonii			4			4							5																					
Descurainia pinnata	40	24	24	16			40	28	44	32	4	12	15	5	10	5			10			15	15	10				10		10	10			
Draba reptans				4					8	4																								
Elymus cinereus																								25										

*Tentative Species Identification

Table XI 42 (Continued)

STAND NO

	1-0	1-f	2-0	2-f	3-0	3-f	4-0	4-f	5-0	5-f	6-0	6-f	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
Erigeron aphanactus *															5																			
Erigeron filifolius*																5																		
Erigeron pumila *																			5	–			–	–										
Erigeron sp.		20	20	16	76	96			4		40	56	50		–		–	70	5	35	100					25	50		–	20				
Erigeron utahensis													[illegible]	70	20	10	55		5				–	10									–	
Eriogonum alatum						16							–		40	40	5		10				–	–										
Eriogonum heracleoides *															30						–	–											–	
Eriogonum lonchophyllum												–	5		20	30	–	–	10				–			55		–						
Eriogonum strictum *											–						20																	–
Eriogonum umbellatum	–	–	–	–	–	–	–	–		–		–	–	–	15	5	–		5		10			–					–					
Erodium cicutarium		4		–	–	–	–	–	–	–	–	–	–		–				–											–	–	–	–	
Erysimum asperum		–	–	–	–	–	–		12	12	4	–	–		–	5		5	–		–						10		–			–		
Euphorbia robusta	–	–		–			–	–	–							5			5						–					–				
Festuca brachyphylla	4	12		4	64	84			4	4	36	68	45	15			25	85		45	75			–		–	60		–					
Gayophytum ramocissimum	12	12	44	36	–	24		–	–		4	–	5					5			5						–		–	10		10		
Haplopappus nuttallii		16				–				–	8	–		20	90	85	–		5	30		–	–	–		–	–							–
Hedysarum boreale	–				16	16				–			5		–	5	25		–	5	10	–	–		–	–	–	–						
Heterotheca villosa	–	–	12	8	–		–		–				5		–					30												–	–	
Heuchera parvifolia	–	–			–		–			–	–	–	–	–	–	–	–	–	–	5	–	–	–	–	–	–	20	–	–					–
Hymenopappus filifolius *								–								5	–					–	–	–	–	–	–	–						–
Hymenopappus lugens		–	–	–	–	–	–	–	–	–	–	–	–	–	55	–	–		–	–	–	–		–		–	–	–		–	–		–	–
Hymenoxis acaulis	–							–		–	–	–	–			20		–		–	–	–	–	–	–	–	–	–	–					–
Ipomopsis aggregata	4		–	–	–	–	–	–	–	–	–	–	–	5		30		10	10	5					5									–
Kochia scoparia *	–	–		–	–	–	–	–	–	–	–	–	–	–	–	–		–		–	–		10	25						–	–			–
Koeleria gracilis (cristata)	4	32	[illegible]	12	100	100	–	–			24	64	55	90	30	40	100	65	45	50	100		–	–			30					–	–	
Lactuca serriola		–						–		–								5	–	–	–		–	–	–	–				–		10	–	–
Lappula redowskii	8	12	36	24			52	16		–	8	8	30	–	–	–	–	–	5	–	–	40	50	–		–	–	10	–		10	10		
Lepidium densiflorum		8								–	–		–				–							–	–	–	–	–	–	–	–	20	–	–
Lepidium montanum	–	–	–	–	–	–	28	48	–	–	–	–	–		40	–		–				40	100	5	50		–	60					20	–
Linum lewisii	–		–		–	–		–	–	–		–	–		–	5	–	–	–	–	–	–	–		–	–	–		–				–	–
Lithospermum sp	–	–	–	–	–	–	–	–	–	–		–	–	–		10	–	–	–	–		–												–
Lolium perenne		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–			–		–										10	20	–	10
Lomatium grayi.*				4		–			–	–			–		–			5	–		30		–	–	–			–		–	–	–	–	–
Lomatium orientale *				–	72	80		–	–	–	4	12			–			–		–						–	–	–	–	–		–	–	–
Lupinus argenteus	4	–	–	–	–	12	–		–	–	–	–	10		–		–	10	15	–	25	–	–	–									–	–
Marrubium vulgare	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–					–			–	5		–	–		–	–	–	–		–
Mentzelia dispersa	8	8	–	8	–	–	–	–	–	–	–	–	10	–	–	15	–	–	–	–	–	–	–	–		–					40	20		–
Microperis cuspidata *	–	–	–	–	–	–	–	–	–	–	–	–	–	15	5	–	–	–	–	–	–	–	–	–		–	–	–	–				–	
Microseris sp. *	–	–	–	–	–	–	–	–	–	–	–	–	10	–	–	–	–	–	–	–			–			–	–	–	–				–	
Microsteris micrantha	–	8	8	4	100	100		–	–	–	–	–	5	–	–	–	–	45	–	–	90	–	–	–	–	–			–	–	–	–	–	–
Nicotiana attenuata	–	–		–	–	–	–	–	–		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–		–	–	–	–	–	–	–
Oenothera caespitosa		–		–	–	–	–	–	–	–		–	–	–	10	20			5	–	–				–	30						–	–	–
Orobanche fasciculata				–	–	–	–	–	–	–	–	–	–	5	–	5	–	–		–	–	–	–	–	–		–	–	–	–	–	–	–	–
Oruzopsis hymenoides	48	64	12	16	–	–	20	32	68	48	4	12	50	30	45	40	75		35	55	–	5	–	–	45	90		30		40	80	80	30	10
Oryzopsis micrantha		–	–	–		–	20		24	32	–	–	–	–	–	–			5		–	–	–	–	–		30	–	–					–
Oxytropis sp	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–			–	–	–	–		–				–	–
Penstemon fremontii	–	–	–	–	52	52	–	–		4		–	–	5		–	10	–	–	–	–	–		–	–	–	–	–	–	–		–		
Penstemon lentus	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	5	–	–	–	–		–			–		–		
Penstemon sp	–	–	4	–	–	–				–		–	–	–	–	5	–	–	–	–	–	–	–		–	15			–	–			–	–
Penstemon watsonii	–		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–		–	–	–
Phlox hoodii	–	32		100	88				–	–	40	64	70	85	35	60	70	45	25	25	–	–	–	–	–	–	–	–	–	–				–
Phlox longifolia	8		4	12	96	100	–	4	–	4	64	68		30	5	15	10	55	5		100							–		–			–	–
Physaria floribunda	–	8	–	–	–	–	8	12	4	–	–			–	30	85	–	–	15	5	35	–	–								–	–	–	–
Poa fendleriana	–	–	–	–	64	92		–	20	20	–	40	–	–	–	25	–		50				–	–	–	–	10	–	–	–		10		–
Poa pratensis	–	4	8	[illegible]	–	–	–			–	–	–	–	–	–	–	–	–	10			–		–	–	–			10				–	–
Poa sp		36	28	24		–	16	4	–	–	–	–	10	45	15							25	75							–	–	–	–	–
Polemoniaceae (unknown)		–		–	–	–	–	–	–	4	–	–	–	–		–		–	–		–	–	–	–	–	–	60						–	–

*Tentative Species Identification

Table XI 42 (Continued)

STAND NO

	1-0	1 f	2-0	2 f	3 0	3-f	4 0	4 f	5 0	5-f	6 0	6 f	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
Polygonum douglasii																																		
Polygonum rurivagum			4	4							4	8	10																		50			
Polygonum sawatchense	12	4				24												50			95													
Polygonum sp														10			25																	
Salsola kali																						5	5			30		100	40	50	10	20	80	30
Senecio ambrosioides																																		
Senecio fremontii *																15																		
Senecio multilobatus		12						4		4	12		15	15		5	15		30	5														
Senecio sp.															10				5								40							
Sisymbrium altissimum															5													80	90	90		20		10
Sisymbrium sp				4									10																					
Sitanion longifolium	20	44	36	36					72	72	8	4	25		5			15	10	35		5					30			10				
Sphaeralcea coccinea			■	4	68	36					20	20		15		5	95	20	5	20	40	25	5		5									
Sporobolus cryptandrus *																						40			35									
Stephanomeria tenuifolia											8	20				40				5														
Stipa comata	20	16		4	8	36	8	8		4	40	28	50	25	20	50	30	70	50		65	80												
Streptanthus cordatus										8									5															
Taraxacum officinale	4	8	16	■		4		4										15		15							20			10			10	
Townsendia sericea	4				8								5	35		15				10														
Tragopogon dubius	4												5					5														10		
Trifolium gymnocarpon					96	88							5								95													
Viola nuttallii							4																											
Yucca glauca																																		
Zigadenus venenosus		4				16						8			5																			
Unknown mustard			4	4			24	4																				10						
Unknown #1																			5							5								
Unknown #3																			5															
Unknown #4																			40															
Unknown #5																			20															
(Woody species) < 25cm																																		
Amelanchier alnifolia		4	4								4						5			10	5													
Artemisia tridentata	12	12	4	8	44	88	44	64			■		20	50		15		10			85	20			20									
Artriplex canescens																																		
Atriplex confertifolia																										60								
Ceratoides lanata					8	16																											20	
Cercocarpus montanus													5																					
Chrysothamnus nauseosus		4	16	8							4											5	20	5	5			10						
Chrysothamnus viscidiflorus			4										10					5	20		60													
Gutierrezia sarothrae	12	24			12	24							15	65	15	50	40		5	40														
Juniperus osteosperma										4																								
Juniperus scopulorum																			5															
Mahonia repens															5																			
Opuntia polyacantha													5	5				5			10													
Pseudotsuga menziesii																											10							
Purshia tridentata	4			4					4				5				10																	
Quercus gambelii																5			5															
Sarcobatus vermiculatus																								15										
Symphoricarpos oreophilus	8			4			4						25					5	15	5	5						80							
Tetradymia canescens																	70	10		5														
Pinus edulis	4			4					■	4	12			5				15	5	5							20							
Aster sp	4	16		12						4			5	5		10							15	20										
Melilotus officinalis																																	50	

* Tentative Species Identification

Table XI–43 MEAN HERB PRODUCTIVITY
FOR PERMANENT PLOTS 1 THROUGH 6*

	May	June	July	August
Stand 1, Chained Pinyon-Juniper Rangeland (Experimental Site)				
lbs/A	124 ± 22	314 ± 43	542 ± 162	255 ± 72
(Kg/HA)	(139 ± 25)	(352 ± 48)	(607 ± 181)	(286 ± 81)
Stand 2,Chained Pinyon-Juniper Rangeland (Control Site)				
lbs/A	127 ± 26	282 ± 40	376 ± 120	228 ± 52
(Kg/HA)	(142 ± 29)	(316 ± 45)	(421 ± 135)	(255 ± 58)
Stand 3,Upland Sagebrush Community				
lbs/A	268 ± 18	464 ± 45	499 ± 37	346 ± 39
(Kg/HA)	(300 ± 20)	(520 ± 50)	(559 ± 42)	(388 ± 44)
Stand 4, Bottomland Sagebrush Community				
lbs/A	72 ± 14	278 ± 33	227 ± 61	120 ± 24
(Kg/HA)	(79 ± 16)	(312 ± 37)	(254 ± 68)	(135 ± 27)
Stand 5, Pinyon-Juniper Woodland (Experimental Site)				
lbs/A	64 ± 16	171 ± 37	207 ± 80	128 ± 46
(Kg/HA)	(72 ± 18)	(192 ± 42)	(232 ± 90)	(143 ± 51)
Stand 6, Pinyon-Juniper Woodland (Control Site)				
lbs/A	107 ± 19	220 ± 41	209 ± 35	270 ± 50
(Kg/HA)	(120 ± 21)	(246 ± 46)	(234 ± 39)	(303 ± 56)

* Plus and minus values are equal to standard error of the mean.

Table XI-44 MEAN STANDING CROP OF SELECTED SHRUB SPECIES
(LBS. PER ACRE)

APRIL, 1975

STAND NO.	SPECIES								
	Amsp*	Artr	Chna	Cemo	Juos	Pied	Putr	Cela	Stand Totals
1	17 ± 4	1186 ± 414	142 ± 27	86 ± 23	24 ± 3	44 ± 6	75 ± 13	–	1574 ± 490
2	104 ± 31	137 ± 34	180 ± 35	56 ± 16	93 ± 12	59 ± 8	62 ± 15	–	691 ± 151
3	–	1351 ± 256	–	–	–	–	–	–	1351 ± 256
4	–	6096 ± 1881	–	–	–	–	–	30 ± 13	6126 ± 1894
5	32 ± 27	124 ± 38	–	52 ± 13	9 ± 1	7 ± 2	19 ± 4	–	243 ± 85
6	78 ± 23	891 ± 272	–	–	26 ± 3	19 ± 3	3 ± 1	–	1017 ± 302

*Amsp - Amelanchier species
Artr - Artemisia tridentata
Cela - Ceratoides lanata
Cemo - Cercocarpus montanus
Chna - Chrysothamnus nauseosus
Juos - Juniperus osteosperma
Pied - Pinus edulis
Putr - Purshia tridentata

Plus/minus figures are equal to the standard error of the mean.

Table XI–45 SOIL MOISTURE CONTENTS IN TRACT C-b VEGETATION TYPES

SOIL MOISTURE (%)

SAMPLE NO. LOCATION	MAR	depth	APR	depth	MAY	depth	JUN	depth	JUL	depth	AUG	depth	SEPT	depth	OCT	depth
1. Chained Pinyon-Juniper Rangeland	80.0	10"	100	10"	38	10"	69.5	10"	43.5	10"	34.5	10"	30.5	10"	30.5	10"
2. Chained Pinyon-Juniper Rangeland	27.8	8"	78	10"	39	10"	55.0	10"	34.0	10"	28.0	10"	24.5	10"	25.0	10"
3. Upland Sagebrush	47.0	8"	85	18"	41	10"	69.0	10"	36.0	10"	36.0	10"	29.5	10"	39.5	10"
4. Bottomland Sagebrush	32.0	16"	76	8"	32	18"	60.0	18"	41.0	18"	28.0	18"	23.0	10"	27.0	10"
5. Pinyon-Juniper Woodland	37.0	10"	82	10"	29	10"	49.0	10"	28.0	10"	25.5	10"	20.5	10"	21.5	10"
6. Pinyon-Juniper Woodland	–	–	83	20"	40	20"	68.5	20"	50.0	10"	42.0	10"	39.0	10"	34.0	10"
7. Chained Pinyon-Juniper Rangeland	–	–	70	10"	–	–	65.0	20"	36.5	10"	40.0	10"	28.0	10"	29.0	10"
8. Bunchgrass Community	31.0	8"	39	17"	14	18"	–	–	–	–	18.0	10"	20.0	10"	13.0	10"
9. Bottomland Sagebrush	23.0	17"	55	15"	21.5	15"	35.0	20"	20.5	10"	21.0	20"	12.0	10"	18.0	10"
10. Rabbitbrush Community	–	–	–	–	–	–	33.9	15"	21.0	10"	22.0	10"	22.0	10"	21.0	10"
11. Bunchgrass Community	33.5	7"	45	7"	20.5	7"	39.0	10"	24.0	10"	23.0	10"	14.0	7"	14.0	7"
12. Bottomland Sagebrush	25.0	18"	40	15"	25.0	20"	45.0	15"	28.0	10"	24.0	10"	22.0	10"	22.0	10"
13. Mixed Mountain Shrubland	44.5	8"	25	8"	28.5	10"	53.0	10"	45.0	10"	37.0	10"	32.0	10"	31.0	10"
14. Pinyon-Juniper Woodland	31.5	18"	77	18"	35.5	20"	58.0	20"	35.0	10"	32.0	10"	30.0	10"	26.0	10"
15. Cottonwood Community	45.5	10"	–	–	40.5	10"	67.0	10"	33.0	10"	19.0	10"	25.0	10"	26.0	10"
16. Bottomland Sagebrush	–	–	–	–	33.5	20"	58.0	10"	35.0	10"	33.0	10"	30.0	10"	29.0	10"
17. Annual Weed Community	62.5	12"	50	8"	34.5	20"	60.5	20"	46.0	10"	24.5	10"	–	–	–	–

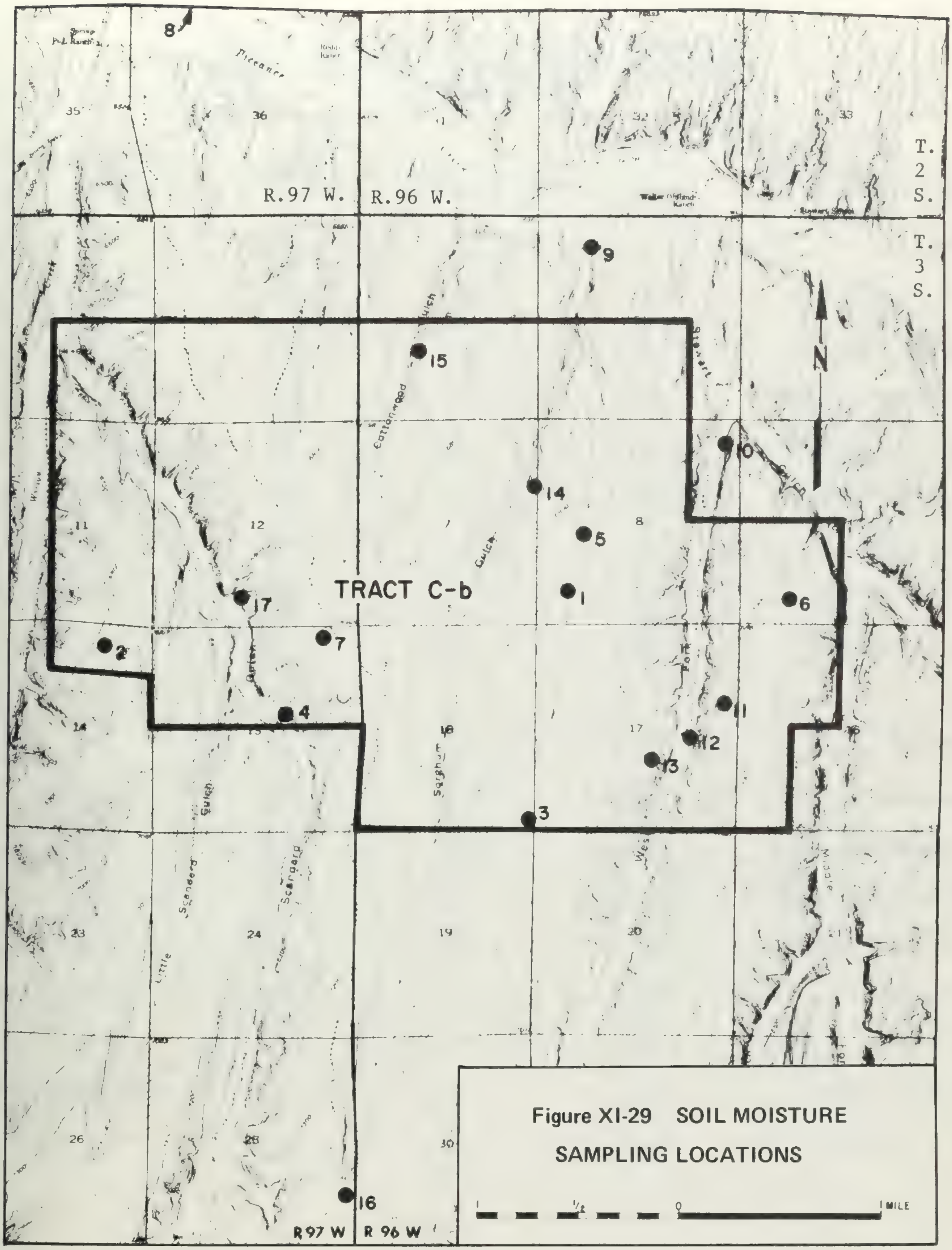


Figure XI-29 SOIL MOISTURE SAMPLING LOCATIONS

Table XI–46 SHRUB LAYER SPECIES COMPOSITION
FOR PINYON-JUNIPER WOODLAND EXPERIMENTAL SITE
(Stand #s 5-f and 5-o)
(VALUES BASED ON 20 2m X 10m SHRUB TRANSECTS.)

SPECIES	COVER %	FREQUENCY %	#/HECTARE	IMPORTANCE VALUE	RANK
Stand 5-f					
Amelanchier spp.	0.2	20	88	41.3	4
Artemisia tridentata	0.8	25	100	86.8	1
Cercocarpus montanus	0.4	30	150	68.3	2
Chrysothamnus nauseosus	<0.1	5	13	5.6	6
Juniperus osteosperma	<0.1	5	13	5.6	7
Pinus edulis	0.2	35	125	54.6	3
Purshia tridentata	<0.1	20	150	37.8	5
TOTALS	1.6		639		
Stand 5-0					
Amelanchier spp.	0.6	50	225	90.0	1
Artemisia tridentata	0.6	25	288	87.1	2
Cercocarpus montanus	<0.1	5	13	4.9	7
Juniperus osteosperma	<0.1	25	50	22.8	4
J. scopulorum	<0.1	10	13	7.9	6
Pinus edulis	1.2	50	13	76.5	3
Purshia tridentata	0.2	5	13	10.8	5
TOTALS	2.6		615		

Table XI–47 SHRUB LAYER SPECIES COMPOSITION
FOR PINYON-JUNIPER WOODLAND CONTROL SITE
(Stand #s 6-o and 6-f)
(VALUES BASED ON 20 2m X 10m SHRUB TRANSECTS.)

SPECIES	COVER %	FREQUENCY %	#/HECTARE	IMPORTANCE VALUE	RANK
Stand 6-f					
Amelanchier spp.	< 0.1	15	63	8.7	5
Artemisia tridentata	1.6	80	1475	185.8	1
C. viscidiflorus		5	13	2.5	6
Juniperus osteosperma	< 0.1	40	150	25.4	3
Opuntia polyacantha	0.1	55	538	50.5	2
Pinus edulis	< 0.1	45	150	24.6	4
Purshia tridentata	___	5	13	2.5	7
TOTALS	1.7		2402		
Stand 6-0					
Amelanchier spp.	0.4	40	200	42.1	2
Artemisia tridentata	1.6	70	1313	156.2	1
Chrysothamnus nauseosus	0.2	15	213	26.7	4
Juniperus osteosperma	< 0.1	10	25	8.0	6
Opuntia polyacantha	0.1	45	325	41.1	3
Pinus edulis	0.3	20	38	22.9	5
Symphoricarpos oreophilus	< 0.1	5	13	3.0	7
TOTALS	2.6		2127		

Table XI–48 SHRUB LAYER SPECIES COMPOSITION
FOR PINYON-JUNIPER WOODLAND CONTROL SITE
(Stand #9)
(VALUES BASED ON 20, 6 FT. X 50 FT. SHRUB TRANSECTS.)

SPECIES	COVER %	FREQUENCY %	#/HECTARE	IMPORTANCE VALUE	RANK
Artemisia tridentata	1.8	35	395	49.8	2
Cercocarpus montanus	<0.1	5	18	2.3	9
Chrysothamnus viscidiflorus	0.6	10	126	15.8	5
Juniperus osteosperma	0.2	25	108	14.8	6
J. scopulorum	<0.1	10	36	4.6	8
Opuntia polyacantha	<0.1	35	251	19.4	4
Pinus edulis	0.6	60	448	41.8	3
Purshia tridentata	3.6	90	2206	145.6	1
Symphoricarpos oreophilus	0.1	10	54	5.8	7
TOTALS	7.2		3642		

Table XI–49 SHRUB LAYER SPECIES COMPOSITION
FOR PINYON-JUNIPER WOODLAND CONTROL SITE
(Stand #12)
(VALUES BASED ON 20 4 FT. X 50 FT. SHRUB TRANSECTS.)

SPECIES	COVER %	FREQUENCY %	#/HECTARE	IMPORTANCE VALUE	RANK
Amelanchier spp.	1.6	45	511	35.0	4
Artemisia tridentata	3.5	95	4545	113.1	1
Chrysothamnus viscidiflorus	0.3	85	2151	46.6	3
Juniperus osteosperma	0.5	5	27	7.5	7
Opuntia polyacantha	0.1	65	1050	28.3	5
Pinus edulis	2.1	65	860	49.6	2
Purshia tridentata	0.2	10	82	5.7	8
Symphoricarpos oreophilus	0.2	35	296	14.2	6
TOTALS	8.5		9522		

Pinyon-juniper woodlands also occur to a limited extent on north-facing slopes. In these stands, the understory is much more dense and has the appearance of a mixed shrub community, except for the presence of the trees. Shrub cover and density are much greater (24% and 26,000 individuals per hectare, respectively). The dominant shrub species in these stands is snowberry (Table XI-50). The herb layer is much better developed in these stands, and herb cover averages 26%. Common understory species are fairy candelabra, Junegrass, western wheatgrass, and needle-and-thread grass (Table XI-40 and XI-42, Stand 13). Pasque flower and sugar bowls, rare species on the Tract, occur in these pinyon-juniper stands.

Considerable variability exists among pinyon-juniper woodlands. Average shrub layer similarity among all sampled pinyon-juniper stands is 48% (Table 51). Similarity is calculated on the basis of the formula C = (2w/a + n) 100, where C = similarity index, w = sum of importance value shared by each species in compared stands, a = sum of importance value in Stand A, and b = sum of importance value in Stand B. Average similarity is computed by determining the arithmetic mean of similarity indices between all possible stand combinations.

The average similarity includes comparision of open understory with dense understory stands. The only stand on the Tract with a dense understory is Stand 13. Recalculation of average similarity excluding data from this stand results in an average similarity of 56%. This suggests less heterogeneity among the open understory pinyon-juniper woodlands.

Stability, Diversity and Succession. The pinyon-juniper woodlands are one of the most stable plant communities in the region. Dendrochronological data show that the oldest trees are more than 2.5 feet (76 cm) in diameter, however, most of the trees are less than 30 feet tall. The pinyons and junipers do not appear to be invading other vegetation types. Saplings occur in the upland sagebrush communities, but establishment of individuals appears to occur intermittently. Herb diversity averages less than 10 species per quadrat, which is an intermediate value compared with other plant communities.

Productivity. Average herb production in the pinyon-juniper woodlands is approximately 240 ± 65 pounds per acre (Table XI-43, Figure XI-30). Production values are lower on hillside communities where May standing crop values are as low as 64 pounds per acre. Maximum values are reached in late July on hillside stands while on ridges maximum standing crop values occur in August. The productivity estimates for pinyon-juniper woodlands reflect the variation in the herbaceous vegetation. Bunchgrasses are common in these communities and the presence or absence of a single bunch in a clipping plot can substantially alter plot values. This effect is accentuated since the herbaceous vegetation between clumps is very sparse. Early in the season when the

Table XI–50 SHRUB LAYER SPECIES COMPOSITION
FOR PINYON-JUNIPER WOODLAND CONTROL SITE
(Stand #13)
(VALUES BASED ON 20, 6 FT. X 50 FT. SHRUB TRANSECTS.)

SPECIES	COVER %	FREQUENCY %	#/HECTARE	IMPORTANCE VALUE	RANK
Amelanchier spp.	3.5	45	2,421	34.2	3
Artemisia tridentata	1.1	35	646	14.9	7
Cercocarpus montanus	1.8	60	1,022	24.9	4
Chrysothamnus nauseosus	0.1	20	90	4.9	11
C. viscidiflorus	0,9	45	520	15.7	6
Juniperus osteosperma	0.2	15	54	4.1	12
J. scopulorum	0.1	30	161	7.4	9
Pinus edulis	0.6	35	197	11.0	8
Purshia tridentata	2.3	45	1,022	23.5	5
Quercus gambelii	4.4	25	4,447	41.7	2
Ribes inerme	0.2	15	287	5.3	10
Rosa woodsii	0.1	5	305	2.5	13
Symphoricarpos oreophilus	9.0	85	14,489	113.9	1
TOTALS	24.3		25,661		

Table XI–51 MATRIX OF SIMILARITY VALUES FOR SAMPLED
PINYON-JUNIPER WOODLAND STANDS

SIMILARITY VALUE

STAND NUMBERS	5–F	509	6–F	6–0	9	12	13
5–F	–	–	–	–	–	–	–
5–0	68.1	–	–	–	–	–	–
6–F	42.7	69.3	–	–	–	–	–
6–0	54.1	53.4	79.0	–	–	–	–
9	45.8	41.4	42.8	34.4	–	–	–
12	60.9	61.6	61.6	73.7	48.6	–	–
13	39.2	29.1	13.7	24.0	24.3	33.3	–

STAND NUMBERS

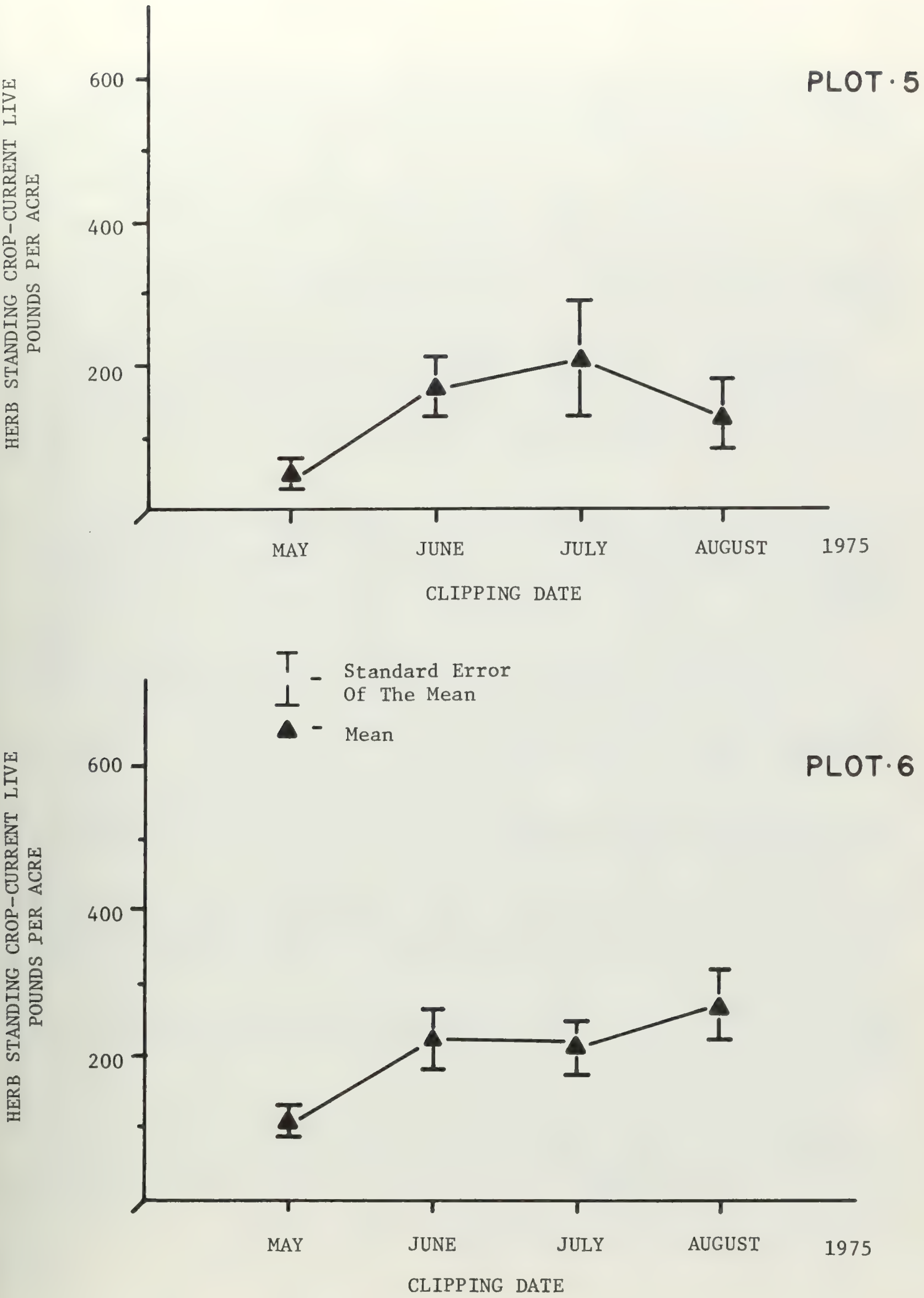


Figure XI-30 CHANGES IN HERBACEOUS STANDING CROP, PINYON-JUNIPER WOODLAND, 1975

individual bunches are small, the differences among samples are not as great. As production peaks are reached later in the season, differences become more pronounced and the sample variance increases.

Mean shrub standing crop for the beginning of the 1975 growing season was approximately 630 $\pm$ 194 pounds per acre (Table XI-44). Production values vary with understory density; the lowest values occurring in hillside stands (243 $\pm$ 85 pounds per acre). The bulk of shrub standing crop in this vegetation type, as well as in all other types, is made up by big sagebrush.

Environment. The pinyon-juniper woodlands are developed mostly on Redcreek and Rentsac channery soils. These soils tend to be thin and are developed over fractured or non-fractured sandstone bedrock. While these soils have adequate levels of nitrogen, they tend to have low or deficient potassium and phosphorus concentrations.

Precipitation values for the Tract are highly variable. Preliminary analysis of data (see below) shows little indication of precipitation patterns with elevation, topography or vegetation types. Most of the precipitation falling in the woodlands either moistens the surface soil layers, evaporates or sublimates, in the case of snow. Runoff is minimal.

Temperature profiles constructed for the four major vegetation types (Figure XI-44, below) show that pinyon-juniper woodlands are the coldest sites. This relationship is true of the entire temperature profile. Effective solar radiation is decreased by canopy cover. This effect is augmented in winter by snow pack.

Soil moisture values fluctuate considerably throughout the season. Values are high in the spring and drop to levels as low as 20% on some sites by September (Table XI-45).

Fires occasionally occur in the pinyon-juniper woodlands. Several burned sites can be found from one fire in the northeast portion of the area between lower Stewart Gulch and Piceance Creek. This fire caused complete destruction of the woodland. Several charred trees remain standing, but most have fallen. Few saplings occur in the area, and the most abundant species is Indian ricegrass. Fires are probably not common since the open canopy and sparse understory do not provide the fuel necessary for frequent fires

Current Land Use and Management. The pinyon-juniper woodlands are used as livestock grazing areas during late spring, summer and early fall. In mid-summer, most of the cattle have moved to higher elevations and are not found on the Tract. Maximum grazing use is in May and October when the livestock are being moved from lower valley winter range to native upland ranges.

Large areas of the Tract woodlands have been chained as part of a range improvement program. By removing the trees, production in herb and shrub layers has been stimulated, thus increasing available forage. After the trees were removed, range grasses were seeded in order to increase grass production.

b. Chained Pinyon-juniper Rangeland

General Location and Distribution. The chained rangelands constitute a highly variable and somewhat artificial plant community. This vegetation type has been produced through management practices of the BLM and its distribution is determined by BLM selection of chaining sites. Chaining is mostly restricted to ridges and gentle hillsides, where it is possible to operate the bulldozers necessary for the chaining operation. On the Tract, the chained rangelands occur primarily in the central portion of the study area and cover approximately 45% of the Tract.

Structure and Composition. The general appearance of the chained rangelands is that of a shrubland with many fallen trees. Total shrub density is approximately 4750 individuals per hectare, and shrub cover averages 11%. The dominant species include big sagebrush, bitterbrush, and saplings of pinyon pine and Utah juniper. In some location, snowberry occurs as a dominant species, but it tends to be locally abundant rater than occurring as a widespread dominant (Tables XI-52, -53, -54, -55, -56, -57 and -58).

Since chaining in 1966, the pinyons and junipers have made some recovery. Average sapling density for these two species were 324 pines per hectare and 260 junipers per hectare.

Cover by herbs in the chained rangelands averages 32%, which is approximately twice the value in pinyon-juniper woodlands. Three perennial grass species are common: Indian ricegrass, squirreltail grass, and western wheatgrass. Many annual species also occur including cheatgrass, goosefoot, stickseed, and tansy mustard, but cheatgrass is the most common (Tables XI-41 and XI-42, Stands 1-0, 1-F, 2-0, 2-F, 7, 10 and 11).

Stability, Diversity and Succession. The chained rangelands constitute ecologically unstable communities. Destruction of the woodlands has greatly altered the original vegetation and has initiated successional changes which will continue until the woodlands become re-established. The observed variation within the chained woodland areas results from original differences in the woodlands and also from differential successional rates. Where environmental factors are more favorable, successional rates will be greater. The heterogeneity is reflected in the average similarity among all sampled stands (53.4%,

Table XI–52 SHRUB LAYER SPECIES COMPOSITION FOR CHAINED PINYON-JUNIPER RANGELAND EXPERIMENTAL SITE
(Stand #1-f)
(VALUES BASED ON 20, 6 FT. X 50 FT. SHRUB TRANSECTS.)

SPECIES	COVER %	FREQUENCY %	#/HECTARE	IMPORTANCE VALUE	RANK
Amelanchier spp.	0.6	15	38	7.9	9
Artemisia tridentata	5.3	80	1600	135.6	1
Cercocarpus montanus	0.1	50	250	24.6	4
Chrysothamnus nauseosus	1.4	50	275	39.8	2
C. viscidiflorus		5	13	1.9	11
Gutierrezia sarothrae	0.5	15	75	12.6	6
Juniperus osteosperma	0.2	25	63	11.9	7
J. scopulorum	< 0.1	5	13	1.9	12
Opuntia polyacantha		10	125	7.3	10
Pinus edulis	0.2	25	163	15.9	5
Purshia tridentata	0.6	50	275	31.0	3
Symphoricarpos oreophilus	0.1	20	75	9.6	8
TOTALS	9.1		2965		

Table XI–53 SHRUB LAYER SPECIES COMPOSITION FOR CHAINED PINYON-JUNIPER RANGELAND EXPERIMENTAL SITE
(Stand #1-o)
(VALUES BASED ON 20, 6 FT. X 50 FT. SHRUB TRANSECTS.)

SPECIES	COVER %	FREQUENCY %	#/HECTARE	IMPORTANCE VALUE	RANK
Amelanchier spp.	0.3	40	188	14.8	5
Artemisia tridentata	9.6	100	2788	147.8	1
Cercocarpus montanus	0.4	65	350	24.7	3
Chrysothamnus nauseosus	0.4	30	188	13.3	7
C. viscidiflorus		5	13	1.4	11
Gutierrezia sarothrae	< 0.1	5	13	1.4	12
Juniperus osteosperma	0.6	40	100	14.6	6
J. scopulorum	1.0	5	25	8.2	9
Opuntia polyacantha		20	100	6.4	10
Pinus edulis	0.8	55	263	23.1	4
Purshia tridentata	1.2	65	525	33.6	2
Symphoricarpos oreophilus	0.2	30	150	10.7	8
TOTALS	14.6		4703		

Table XI–54 SHRUB LAYER SPECIES COMPOSITION FOR CHAINED PINYON-JUNIPER RANGELAND CONTROL SITE
(Stand #2-f)
(VALUES BASED ON 20, 6 FT. X 50 FT. SHRUB TRANSECTS.)

SPECIES	COVER %	FREQUENCY %	#/HECTARE	IMPORTANCE VALUE	RANK
Amelanchier spp.	<0.1	30	100	15.9	6
Artemisia tridentata	1.1	35	250	37.4	4
Cercocarpus montanus	0.4	10	63	11.1	7
Chrysothamnus nauseosus	0.6	50	225	36.0	5
C. viscidiflorus	<0.1	5	0	1.6	9
Juniperus osteosperma	2.8	70	413	76.7	1
Opuntia polyacantha	<0.1	10	50	6.1	8
Pinus edulis	1.2	65	288	49.8	3
Purshia tridentata	3.2	35	350	65.4	2
TOTALS	9.6		1739		

Table XI–55 SHRUB LAYER SPECIES COMPOSITION FOR CHAINED PINYON-JUNIPER CONTROL SITE
(Stand #2-o)
(VALUES BASED ON 20, 6 FT. X 50 FT. SHRUB TRANSECTS.)

SPECIES	COVER %	FREQUENCY %	#/HECTARE	IMPORTANCE VALUE	RANK
Amelanchier spp.	0.2	20	75	14.0	7
Artemisia tridentata	0.3	50	188	31.3	4
Cercocarpus montanus	0.3	25	50	15.5	6
Chrysothamnus nauseosus	2.6	85	363	93.5	1
C. viscidiflorus	<0.1	5	13	2.2	10
Gutierrezia sarothrae	<0.1	5	13	2.2	11
Juniperus osterosperma	1.3	50	213	51.3	2
Opuntia polyacantha		35	125	17.7	5
Pinus edulis	0.8	65	288	50.2	3
Purshia tridentata	<0.1	20	100	11.9	8
Symphoricarpos oreophilus	<0.1	10	100	10.2	9
TOTALS	5.9		1528		

Table XI–56 SHRUB LAYER SPECIES COMPOSITION FOR
CHAINED PINYON-JUNIPER RANGELAND
(Stand #7)
(VALUES BASED ON 20, 6 FT. X 50 FT. SHRUB TRANSECTS.)

SPECIES	COVER %	FREQUENCY %	#/HECTARE	IMPORTANCE VALUE	RANK
Amelanchier spp.	1.4	20	377	18.5	4
Artemisia tridentata	4.6	80	2528	78.5	2
Cercocarpus montanus	0.1	35	430	13.9	6
Chrysothamnus nauseosus	0.2	15	72	5.9	11
C. viscidiflorus	<0.1	25	126	7.5	9
Juniperus osteosperma	0.9	55	341	23.3	3
Opuntia polyacantha	0.2	45	466	17.5	5
Pinus edulis	0.2	35	251	12.6	7
Purshia tridentata	0.6	20	179	11.0	8
Quercus gambelii	0.4	5	287	7.1	10
Symphoricarpos oreophilus	6.1	75	4035	104.2	1
TOTALS	14.8		9092		

Table XI–57 SHRUB LAYER SPECIES COMPOSITION FOR
CHAINED PINYON-JUNIPER RANGELAND
(Stand #10)
(VALUES BASED ON 20, 6 FT. X 50 FT. SHRUB TRANSECTS.)

SPECIES	COVER %	FREQUENCY %	#/HECTARE	IMPORTANCE VALUE	RANK
Amelanchier spp.	0.1	15	179	9.9	5
Artemisia tridentata	3.8	60	3658	124.5	1
Chrysothamnus nauseosus	0.4	10	72	9.0	7
C. viscidiflorus	<0.1	5	18	2.3	10
Juniperus osteosperma	0.3	30	126	16.6	4
J. scopulorum	0.1	15	54	7.9	8
Opuntia polyacantha	<0.1	10	72	6.2	9
Pinus edulis	0.6	45	269	28.9	3
Purshia tridentata	3.8	50	1542	86.5	2
Symphoricarpos oreophilus	0.1	15	179	9.9	6
TOTALS	9.4		6169		

Table XI-59). The fact that this value is somewhat higher than the average value for pinyon-juniper woodland most likely relects the lack of chained sites on north-facing slopes. The intensive study (permanent) sites are 50% similar to the other sampled chained sites.

Successional changes within these communities will take place slowly. It may take as long as 200 years for these sites to return to a woodland vegetation.

Production. Herb shoot production in the chained rangelands averages 459 ± 141 pounds per acre per year. Standing crop values average 125 pounds per acre in May and reach maximum values in July. The pattern of increasing herb variation later in the growing season, characteristic of pinyon-juniper woodlands, is also apparent in the chained pinyon-juniper rangelands (Table XI-43, Figure XI-31). Production in the chained rangelands shows the greatest variation of any of the vegetation types, and is the second most productive in terms of herb standing crop.

Mean standing crop for shrubs for April 1975 is approximately 1133 ± 321 pounds per acre (Table XI-44). This value is based on preliminary shoot clips from six important shrub species.

Environment. Soils in the chained rangelands have essentially the same characteristics as in the pinyon-juniper woodlands. However, other environmental factors have been altered as a result of chaining. Solar radiation is much more uniform in the chained areas because of the absence of a tree canopy. Radiation intensities are reduced under the fallen timber, however these conditions are different from those produced by a vegetation canopy.

Chained sites are the warmest of the four vegetation types on Tract C-b (Figure XI-44, below). Differences in temperature between extremes in depth and height are the greatest of all sites. The behavior of the temperature profile is markedly similar to that of the woodland sites. The extreme difference in actual mean temperature between the chained areas and the woodland sites is due to the absence of canopy cover in the former type.

Snow distributional patterns have been altered as a result of chaining. Snow tends to collect in the lee of the windrows of fallen trees, thus producing an effect on the distribution of soil moisture.

Fires could occur within the chained areas, and the fallen timber would supply an abundance of fuel. To date, however, no evidence of fire has been observed in the chained areas.

Current Land Use and Management. Currently the chained rangelands are used for cattle grazing. Since chaining, no further management practices have been employed in this vegetation type.

Table XI–58 SHRUB LAYER SPECIES COMPOSITION FOR CHAINED PINYON-JUNIPER RANGELAND
(Stand #14)
(VALUES BASED ON 20, 4 FT. X 50 FT. SHRUB TRANSECTS.)

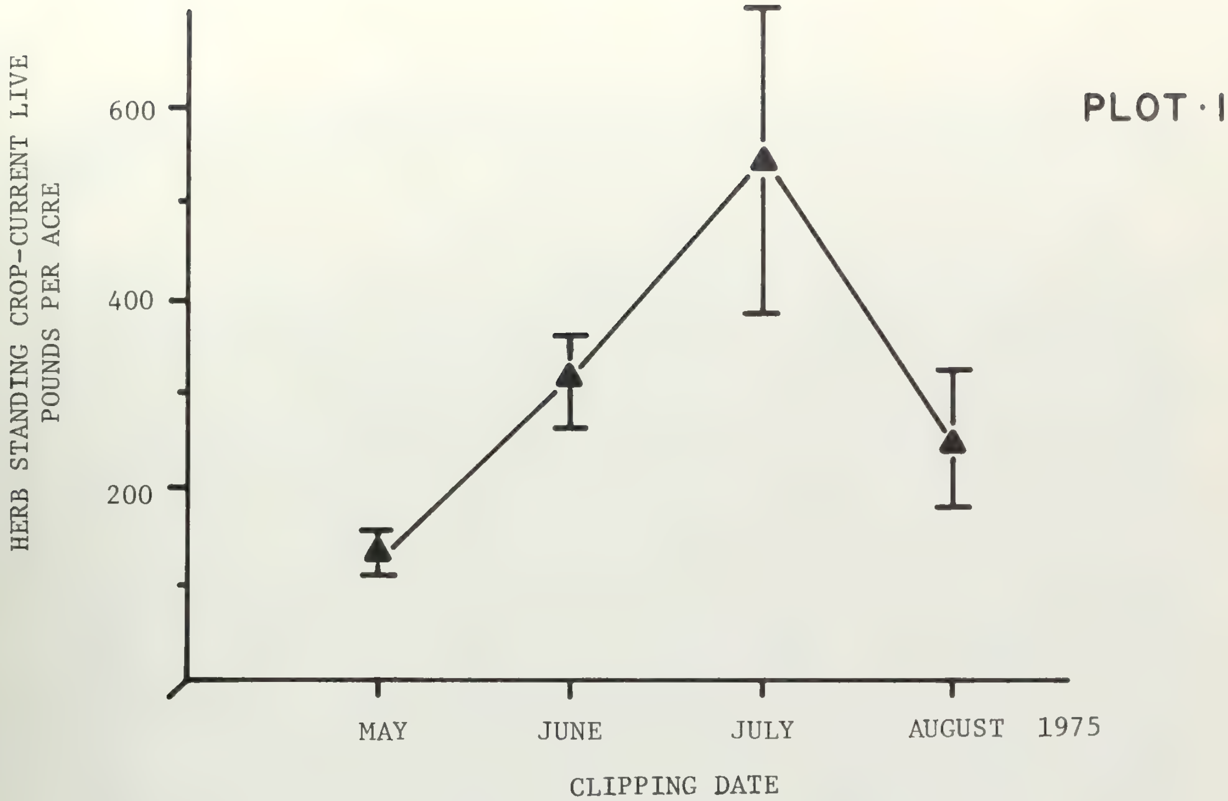
SPECIES	COVER %	FREQUENCY %	#/HECTARE	IMPORTANCE VALUE	RANK
Amelanchier spp.	1.1	45	860	31.3	4
Artemisia tridentata	<0.1	10	54	3.2	9
Cercocarpus montanus	3.2	55	808	49.1	2
Chrysothamnus nauseosus	<0.1	5	27	1.6	10
Chrysothamnus viscidiflorus	0.3	50	618	22.9	6
Juniperus osteosperma	1.0	55	566	29.2	5
Opuntia polyacantha	<0.1	5	27	1.6	11
Pinus edulis	1.2	75	753	38.3	3
Purshia tridentata	1.2	20	296	17.9	7
Symphoricarpos oreophilus	5.2	80	2905	100.9	1
Tetradymia canescens	<0.1	10	109	4.0	8
TOTALS	13.6		7023		

Table XI–59 MATRIX OF SIMILIARITY VALUES FOR SAMPLED CHAINED RANGELAND STANDS

SIMILARITY VALUE

STAND NUMBERS	1–F	1–0	2–F	2–0	7	10	14
1–F	–	–	–	–	–	–	–
1–0	87.0	–	–	–	–	–	–
2–F	52.0	51.8	–	–	–	–	–
2–0	51.0	59.5	71.1	–	–	–	–
7	53.5	56.6	38.9	47.3	–	–	–
10	73.3	80.0	58.2	41.9	51.0	–	–
14	32.0	37.8	40.1	42.6	64.7	30.6	–

STAND NUMBERS



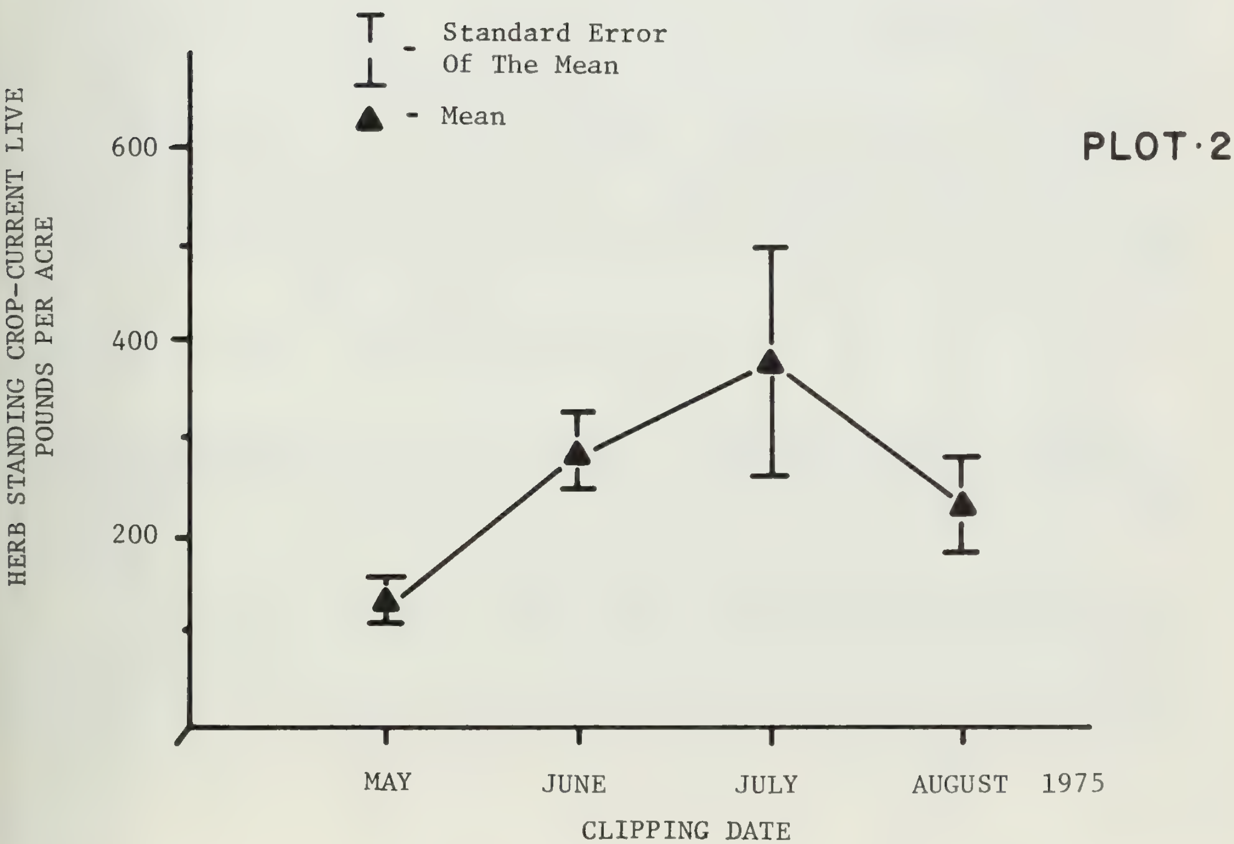


Figure XI-31 CHANGES IN HERBACEOUS STANDING CROP, CHAINED PINYON-JUNIPER RANGELANDS, 1975

Additionally, these sites are used as firewood cutting areas under permits issued by the BLM. Woodcutters selectively remove trunks and larger branches, but leave behind tree bases, roots and smaller branches.

c. Big Sagebrush Communities

Big sagebrush communities are widely distributed throughout the Piceance Creek basin and occur as two structurally different types. On lower valley floors and on alluvial fans, big sagebrush occurs at very high densities and attains heights in excess of three meters. Big sagebrush also occurs in nearly pure stands on ridges and clearings in the pinyon-juniper woodlands. On these sites, the sagebrush is much smaller in stature and does not reach densities as great as those attained in the valley communities. The ridgetop communities extend to elevations as high as 8500 feet. Variation in the size and density of sage plants in the valleys results from the number of environmental parameters as well as possible genetic sub-specific differences. The upland sagebrush sites occur primarily on Forelle and Piceance Loam soils which are generally characterized by low or deficient sulfate, phosphorus and potassium concentrations. The bottomland sagebrush stands, however, occur on Glendive and Hanly Loam soils which are characterized by normal, high or excessive amounts of these same nutrients. Differences in sagebrush size may result from differing concentrations of these major plant nutrients. Additionally, the effect of total salt concentration may be playing an important role in causing sagebrush community differences. Total salts tend to be excessive in the valleys and deficient on the uplands. Soil moisture values for March through October averaged 43% in the upland sagebrush sites and only 32% in the bottomland sites (Table XI-45). These differences may result from differences in soil texture (the Piceance and Forelle Loams tend to have higher clay content and better water retaining characteristics). The higher soil moisture levels on the ridges are important for the growth and development of the numerous herbaceous species which characterize the upland sites.

(1) Upland Sagebrush Communities

<u>General Location and Distribution</u>. Within the Tract study area, the upland sagebrush communities occur on broad ridgetops and in clearings within the pinyon-juniper woodlands. This community type usually does not develop on sloping sites.

<u>Structure and Composition</u>. The dominant species in the upland sagebrush communities is big sagebrush which occurs at an average density of 10,500 individuals per hectare. Other shrub species are relatively unimportant in these communities. Saplings of pinyon pine and juniper commonly occur, but density values for these species are

low. Prickly pear (Opuntia polyacantha) is a common shrub layer component on many of the upland sagebrush types. (Tables XI-60 through XI-63).

The herb layer is composed of many species which occur at high frequency values. Western wheatgrass, Junegrass, long-leaved phlox, false dandelion, mariposa lily, Trifolium gymnocarpon, and Microsteris micrantha are all common species which occur at nearly 100% frequency. (Tables XI-41 and XI-42, Stands 3-0, 3-F, 8, 11 and 15). Cover by herbs in these communities averages 45%. Mosses and lichens occur only around the bases of the individual sagebrush plants. Accumulation of litter and moisture from snow and branch runoff provide suitable moss and lichen habitat only in these microsites.

The upland sagebrush sites are quite homogeneous. The average similarity value based on shrub importance values among all samples stands was 74% (Table XI-64). The permanent study sites (Stands 3-0 and 3-f) have an average of 79% similarity with other upland sites. Values greater than 80% indicate high vegetational similarity. Some of the upland sites are more than 90% similar.

Stability, Diversity and Succession. The upland sagebrush communities on the Tract constitute an ecologically stable vegetation type. Several observations point to the long standing presence of this vegetation unit. Herb diversity in these communities is high (14.1 species per square meter). In this region, it appears that considerable time periods are required for species diversity to reach this level. Factors other than time are also important in determining diversity, but the herb complexity in this vegetation type certainly suggests long-term stability. The growth of sagebrush is such that it is possible to determine approximate ages by counting growth rings in stem cross sections. The ages obtained for ridgetop plants represent minimal estimates since the plants are multiple stemmed and as older stems die, new shoots develop. The older sagebrush stems are approximately 50 years old. In addition, sagebrush plants in size classes (seedlings and mature plants) suggest an equilibrium state with local environmental conditions.

These sagebrush stands are not successional. In some places, pinyon and juniper saplings occur; however, density values for these species are low and suggest only occasional successful establishment. At higher elevations, there is a greater component of mixed mountain shrubland species in the sagebrush communities.

Productivity. The herbaceous plants in the upland sagebrush sites begin growth in mid-to-late-April and by mid-May herb standing crop values are approximately 300 pounds per acre. Total current live standing crop increases during June and reaches a maximum value of 560 pounds per acre in mid-July. Plants begin senescing after this date and total standing crop decreases to approximately 400 pounds per acre in

Table XI–60 SHRUB LAYER SPECIES COMPOSITION FOR
UPLAND SAGEBRUSH COMMUNITY
(Stand #s 3-f and 3-o)
(VALUES BASED ON 20 2m X 10m SHRUB TRANSECTS.)

SPECIES	COVER %	FREQUENCY %	#/HECTARE	IMPORTANCE VALUE	RANK
Stand 3–F					
Artemisia tridentata	5.2	100	7050	243.6	1
Gutierrezia sarothrae	<0.1	15	63	8.7	4
Juniperus osteosperma	0.1	5	13	2.8	5
Opuntia polyacantha	<0.1	55	288	32.8	2
Pinus edulis	0.2	15	38	12.1	3
TOTALS	5.4		7452		
Stand 3–0					
Amelanchier spp.	<0.1	40	150	16.8	3
Artemisia tridentata	10.0	100	8500	224.8	1
Chrisothamnus nauseosus	0.1	10	25	5.0	6
C. viscidiflorus	<0.1	5	13	2.0	7
Gutierrezia sarothrae	<0.1	40	100	16.7	4
Opuntia polyacantha	<0.1	35	100	14.8	5
Pinus edulis	0.6	35	113	19.9	2
TOTALS	10.7		9001		

Table XI–61 SHRUB LAYER SPECIES COMPOSITION FOR
UPLAND SAGEBRUSH COMMUNITY
(Stand #8)
(VALUES BASED ON 20, 6 X 50 SHRUB TRANSECTS.)

SPECIES	COVER %	FREQUENCY %	#/HECTARE	IMPORTANCE VALUE	RANK
Artemisia tridentata	17.7	100	13,736	247.3	1
Chrysothamnus nauseosus	0.2	10	144	7.5	5
C. viscidiflorus	< 0.1	10	72	5.9	6
Juniperus osteosperma	0.4	15	108	10.9	3
Opuntia polyacantha	< 0.1	35	144	19.8	2
Pinus edulis	< 0.1	15	72	8.6	4
TOTALS	18.6		14,276		

Table XI–62 SHRUB LAYER SPECIES COMPOSITION FOR UPLAND SAGEBRUSH COMMUNITY
(Stand #11)
(VALUES BASED ON 20, 6 X 50 SHRUB TRANSECTS.)

SPECIES	COVER %	FREQUENCY %	#/HECTARE	IMPORTANCE VALUE	RANK
Amelanchier spp.	<0.1	5	72	2.6	6
Artemisia tridentata	17.4	100	13,539	235.9	1
Juniperus osteosperma	0.1	15	54	7.1	4
J. scopulorum	<0.1	15	72	6.9	5
Opuntia polyacantha	0.2	50	359	24.9	2
Pinus edulis	0.2	45	179	21.5	3
Symphoricarpos oreophilus	<0.1	5	18	2.2	7
TOTALS	18.2		14,293		

Table XI–63 SHRUB LAYER SPECIES COMPOSITION FOR UPLAND SAGEBRUSH COMMUNITY
(Stand #15)
(VALUES BASED ON 20 4 X 50 SHRUB TRANSECTS.)

SPECIES	COVER %	FREQUENCY %	#/HECTARE	IMPORTANCE VALUE	RANK
Amelanchier spp.	3.9	100	2823	49.2	3
Artemisia tridentata	18.1	100	9710	133.8	1
Chrysothamnus viscidiflorus	1.2	95	8151	58.8	2
Opuntia polyacantha	<0.1	10	81	2.6	7
Pinus edulis	<0.1	30	242	7.7	5
Purshia tridentata	<0.1	5	27	1.2	8
Symphoricarpos oreophilus	1.9	85	3767	41.6	4
Tetradymia canescens	<0.1	20	133	5.0	6
TOTALS	25.5		24934		

Table XI–64 MATRIX OF SIMILARITY VALUES FOR SAMPLED UPLAND SAGEBRUSH STANDS

SIMILARITY VALUE

STAND NUMBERS	3–F	3–0	8	11	15
3–F	–	–	–	–	–
3–0	86.8	–	–	–	–
8	91.6	85.1	–	–	–
11	91.9	87.4	90.5	–	–
15	48.0	54.3	50.3	52.0	–

STAND NUMBERS

Table XI–65 SHRUB LAYER SPECIES COMPOSITION FOR BOTTOMLAND SAGEBRUSH COMMUNITY
(Stand #s 4-f and 4-o)
(VALUES BASED ON 20, 6' X 50' SHRUB TRANSECTS.)

SPECIES	COVER %	FREQUENCY %	#/HECTARE	IMPORTANCE VALUE	RANK
Artemisia tridentata	29.6	100	16,875	232.8	1
Chrysothamnus nauseosus	<0.1	10	50	5.6	3
Ceratoides lanata	1.8	70	2,588	55.9	2
Opuntia polyacantha	<0.1	5	88	3.0	4
Purshia tridentata	<0.1	5	13	2.7	5
TOTALS	31.7		19,614		
Artemisia tridentata	36.8	100	22,513	258.1	1
Chrysothamnus nauseosus	<0.1	15	63	9.4	4
Ceratoides lanata	0.1	15	213	10.3	3
Opuntia polyacantha	0.2	35	125	22.2	2
Purshia tridentata	<0.1	0	0	0.0	5
TOTALS	37.3		22,914		

August (Figure XI-32, Table XI-43). Next to the chained rangeland sites, these communities have the greatest herb layer production. Production is more uniform on a unit area basis here than in other communities. The presence of western wheatgrass and Junegrass as dominant species rather than bunchgrasses reduces the between plot variance characteristic of the other vegetation types.

Mean shrub standing crop in upland sagebrush communities for the start of the growing season in 1975 is based on shoot harvest from big sagebrush. These values are approximately 1351 $\pm$ 256 pounds per acre.

Environment. The important features of the soil characteristics within this vegetation type have been mentioned above.

The temperature profile for this community type shows more vertical mixing than do the other three major vegetation types (Figure XI-44, below). This is reflected by the small differences in temperature at the surface and in free air one meter above the surface. This relationship appears to be the result of the low profile of the vegetation, which has little retardant effect on circulating air. In contrast, the remaining community types display structural features which channel and buffer moving air. Temperatures in upland sagebrush communities are intermediate with respect to the remaining three vegetation types. The greater response of soils at depth is the apparent result of fine-textured soils in combination with good vertical mixing in the air immediately above the surface.

Snow accumulation is important in this community as a source of soil moisture. During the winter, snow accumulates to a depth approximately equal to the height of the shrubs. As the snow melts in spring, most of the moisture penetrates into the soil and very little runs off. Soil moisture conditions remain favorable throughout the growing season because of the deep nature of the loamy soils.

Fires occur occasionally in the upland sagebrush communities. Sites most likely to burn are those which occur as clearings within the woodlands. The incidence of fire is not frequent enough to suggest that it is the factor governing the distribution of this vegetation type.

Current Land Use and Management. The upland sagebrush areas are used for livestock grazing. Cattle utilize these areas mostly in May and early June, and again in late September and early October. During the major part of the growing season, the cattle graze at higher elevations.

Various management techniques have been used in the upland sagebrush communities. Some of the upland sites were chained along with the

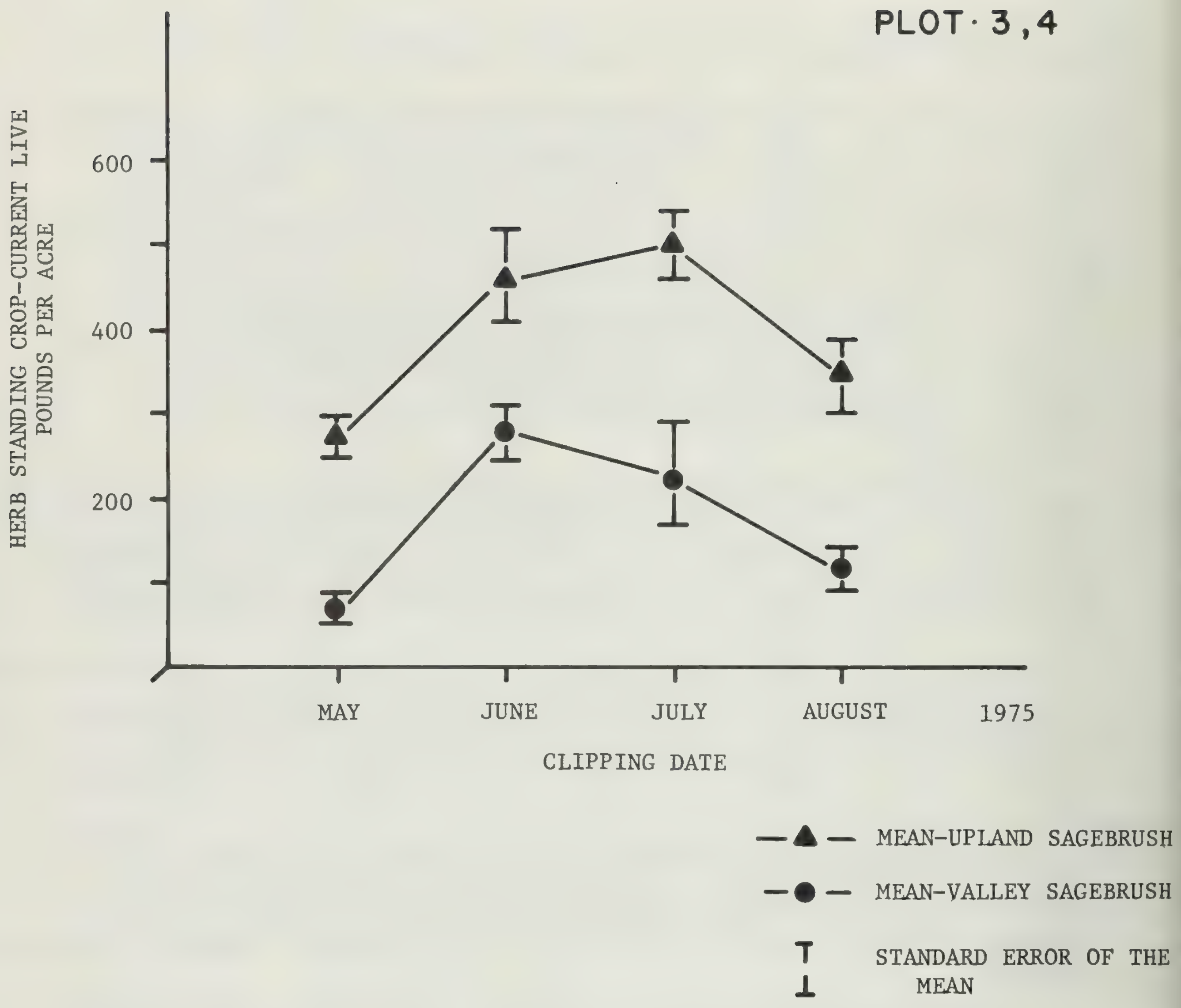


Figure XI-32 CHANGES IN HERBACEOUS STANDING CROP, BIG SAGEBRUSH COMMUNITIES, 1975

pinyon-juniper woodlands. The sagebrush does not appear to have been greatly affected by this management approach. No other management practices have been used in the upland sagebrush communities.

(2) Bottomland Sagebrush Communities

General Location and Distribution. The bottomland sagebrush communities typically occur in the valley floors and alluvial fans of the gulches throughout the Piceance Creek basin. The larger valleys which contain intermittent streams usually are dominated by this vegetation type. Stands of bottomland sagebrush occur at the mouths of most of the small gulches which feed into the major drainages. Narrow strips of sagebrush vegetations follow the intermittent stream channels into the small draws.

Within the Tract study area, the best developed areas of bottomland sagebrush occur in Scandard Gulch and along West Fork Stewart Creek.

Structure and Composition. The overwhelmingly dominant species in these communities is big sagebrush which provides an average cover of 37% and occurs at an approximate density of 1800 individual plants per hectare (Tables XI-65 through XI-67). Prickly pear and winter fat also occur but have low cover and density values. Winter fat reaches its greatest cover and density in the big sagebrush communities. Other shrub species may be encountered in these communities, but they comprise a minor component of the vegetation. Density of sagebrush in the bottomlands is 1.7 times greater than on the uplands.

The herb layer in the bottomland sagebrush communities is very different from that in the upland communities. The dominant species are cheatgrass, goosefoot, stickseed and mountain peppergrass which are all characteristic of disturbed sites. The first three species are annuals. Cheatgrass occurs at an average frequency of 100% in the four sampled bottomland sagebrush stands (Tables XI-41 and XI-42, Stands 4-0, 4-F, 16 and 19). The most common perennial species was western wheatgrass.

Stability, Diversity and Succession. The widespread distribution and internal homogeneity of this vegetation type suggest its long-term role in regional vegetation dynamics. All sizes (age classes) of big sagebrush plants occur within the stands (seedlings as well as old, fallen decomposing stems). The oldest plants (estimated ages based on growth ring counts) are approximately 70 years old. Based on shrub importance value, the average similarity among sampled bottomland sagebrush stands is 84.5% (Table XI-68). Some of the similarity values between stands are in the range of 90%, which suggests a very homogeneous vegetation type. Average similarity between the permanent study sites and other bottomland sagebrush stands was approximately 84%.

Table XI–66 SHRUB LAYER SPECIES COMPOSITION FOR BOTTOMLAND SAGEBRUSH COMMUNITY
(Stand #16)
(VALUES BASED ON 20, 6 X 50 SHRUB TRANSECTS.)

SPECIES	COVER %	FREQUENCY %	#/HECTARE	IMPORTANCE VALUE	RANK
Artemisia tridentata	40.8	100	15,278	225.6	1
Chrysothamnus nauseosus	4.4	55	2,242	49.8	2
Opuntia polyacantha	0.1	30	215	16.4	3
Symphoricarpos oreophilus	.1	15	108	8.2	4
TOTALS	45.4		17,843		

Table XI–67 SHRUB LAYER SPECIES COMPOSITION FOR BOTTOMLAND SAGEBRUSH COMMUNITY
(Stand #19)
(VALUES BASED ON 20, 6 X 50 SHRUB TRANSECTS.)

SPECIES	COVER %	FREQUENCY %	#/HECTARE	IMPORTANCE VALUE	RANK
Artemisia tridentata	38.9	100	17,502	261.8	1
Chrysothamnus nauseosus	2.5	30	502	30.	2
Opuntia polyacantha	.1	10	72	7.	3
TOTALS	41.5		18,076		

Table XI–68 MATRIX OF SIMILARITY VALUES FOR SAMPLED BOTTOMLAND SAGEBRUSH STANDS

SIMILARITY VALUE

STAND NUMBERS	4–F	4–0	16	19
4–F	–	–	–	–
4–0	84.9	–	–	–
16	78.1	83.8	–	–
19	80.5	91.7	87.7	–

STAND NUMBERS

Apparently, the high salt concentrations which characterize the soil in these communities are detrimental to the development of a diverse understory. Herb diversity averages only 4.8 species per square meter, compared with 14.1 species per square meter in the upland sagebrush communities.

The bottomland sagebrush community is not successional and shows no strong developmental relationship coincident with settlement by early ranchers in the late 1800's. Agricultural disturbances within these communities seem to favor the development of communities dominated by rabbitbrush rather than by big sagebrush.

Productivity. Herb production in the bottomland sagebrush results primarily from the growth of annual species, primarily cheatgrass. Maximum standing crop is attained in June (one month earlier than in upland sagebrush communities) and net shoot production is only 56% as great as in upland sites (278 pounds dry weight per acre). Herb standing crop values start low in May (71 pounds dry weight per acre) and increase rapidly to maximum values in June. This growth pattern is very characteristic of cheatgrass which matures and begins to senesce by early July. Standing crop values decrease after June maximums, and by August current live values are only 120 pounds dry weight per acre (Table XI-43, Figure XI-32). Late season current live values result mostly from western wheatgrass, a perennial, which matures later in the season.

Mean standing crop based on big sagebrush and winterfat was approximately 6126 $\pm$ 1894 pounds per acre for April 1975. These extremely high values are directly related to the size and density of big sagebrush in this stand type, and are related to low browse utilization in these stands.

Environment. The importance of soil nutrients and soil moisture in these plant communities was previously discussed. Other environmental factors are probably less important in determining the distribution of this vegetation type.

The unique temperature feature of this vegetation type is the behavior of the subsurface temperatures (Figure XI-44, below). This type displays a perturbation at depth so that the extreme subsurface is colder than shallow soil areas during both warm and cold weather. This differs from the characteristic pattern of gradual temperature decrease with depth in warm weather and the gradual increase of temperature with depth in cold weather. In this vegetation type, the shallow soil areas are either warmer than the surface or about the same temperature. The probable mechanism responsible for this phenomenon is the poor mixing of air above the surface. This effect is produced by dense vegetation which is more than one meter in height in combination with adequate heating of the fine-textured soils.

The lower average temperatures at one meter, in contrast to upland sagebrush stands, are the result of cold air drainage in bottomland sites. Apparently, the vegetation height is responsible for limiting the effects of cold air drainage to the level of the shrub crown.

Fire probably occurs periodically in the bottomland, however, it does not play an important role in this community type. It is possible that fire may have been used to clear portions of valley bottoms during settlement days, since sagebrush is intolerant of burning.

Current Land Use and Management. The bottomland sagebrush communities are currently used for livestock grazing. Cattle utilize the areas in spring and fall, but during summer most of the cattle are found at elevations higher than the Tract.

Some of the bottomland sagebrush stands have been sprayed with herbicide in order to eliminate the sagebrush and encourage the growth of forage species. Most of this activity has occurred within the study area on private land outside the Tract boundaries. Spraying successes vary and on some sites sagebrush kill has been nearly complete (along Willow Creek). Rabbitbrush appears to be more tolerant of the herbicide and has assumed a dominant role on some sprayed sites.

d. Douglas-fir Forests

General, Location and Distribution. The Douglas-fir forests are a common vegetation type at higher elevations in the Piceance Creek Basin. In the southern portion of the basin they occur primarily on north-facing slopes and individual forests may cover many acres. In the northwestern portion of the basin, stands of Douglas-fir are much less common, and in this region the north-facing sites are dominated by aspen. Transitional stands exist in which both aspen and Douglas-fir are greatly restricted, and the stands which occur are usually composed of only a few trees. Aspen does not occur at these lower elevations.

In the Tract study area, small isolated stands of Douglas-fir occur in the draws on the south side of Piceance Creek valley, and also to a lesser extent in the small draws which drain into West Fork Stewart Creek. In only one or two locations is the tree density great enough to form true forest conditions.

Structure and Composition. The stands of Douglas-fir which occur on the Tract are composed of only a few scattered trees. The stand near the mouth of Sorghum Gulch is a typical example of this vegetation type. At this sampling location only fourteen trees were measured. Several isolated trees occurred along the stream channel but these were not included in the sample. Tree diameters averaged 10.5 inches (26.7 cm) and ranged from 6.7 inches (17.0 cm) to 14.9 inches (37.8 cm). The larger trees were approximately 60 feet tall. The poorly developed tree

layer has done little to modify the understory. The areas immediately underneath the trees are covered by fallen needles and very few herbaceous plants grow in this substrate.

The shrub layer is composed of species which also occur in the mixed mountain shrublands and indicate the similarity of these two vegetation types. Gambel's oak and snowberry were the dominant species and occurred at densities of approximately 8200 and 7500 plants per hectare, respectively (Table XI-69). The absence of Douglas-fir saplings in the sample suggests that reproductive success for this species is limited in this local area. It is likely that germination and successful establishment of Douglas-fir in these stands occurs only during the most favorable year.

The herb layer in these communities is discontinuous and average herb cover is approximately 25% (Table XI-41 and XI-42, Stand 21). Common species include fairy candelabra, pussytoes, and sheep fescue. Mosses and lichens are common in this community, and together they cover nearly 30% of the ground layer (Tables XI-41 and XI-42).

Stability, Diversity and Succession. Under the existing climatic regime, the low elevation Douglas-fir forests appear to be in equilibrium with the environmental parameters. This vegetation type occurs in very restricted sites, and sampling data suggest poor reproductive success. It is possible that only a slight climatic change to warmer, drier conditions could cause these communities to shift in the direction of pinyon-juniper woodlands. In the Tract area, stands of pinyon-juniper occur which contain few isolated Douglas-fir trees, suggesting the close relationship between these two types.

Herb layer diversity in the Douglas-fir forests is intermediate compared with other communities and averages 7.5 species per square meter.

Environment. The Douglas-fir forests occur mostly on Rentsac Channery soils on the Tract. The relationship with soil type is probably of secondary importance, and the distribution of this vegetation type is probably controlled more by temperature and moisture than by soil type. The steep north-facing slopes on which these communities occur tend to be cooler and more moist than surrounding sites. Even though these conditions are similar to those encountered in mixed shrub communities, Douglas-fir seems to be restricted to those sites where northerly exposure and steepness are greatest.

Fires occur in the stands of Douglas-fir, but are apparently not a factor controlling their distribution. Burned areas occur mostly in the pinyon-juniper woodlands, and where Douglas-fir existed adjacent to these sites, they also have been destroyed by fire.

Table XI–69 SHRUB LAYER SPECIES COMPOSITION FOR DOUGLAS-FIR FOREST
(Stand #21)
(VALUES BASED ON 10, 5 X 20 SHRUB TRANSECTS.)

SPECIES	COVER %	FREQUENCY %	#/HECTARE	IMPORTANCE VALUE	RANK
Cercocarpus montanus	0.3	10	109	7.4	6
Juniperus scopulorum	0.5	20	430	16.0	4
Pinus edulis	<0.1	20	215	11.8	5
Quercus gambelii	10.3	50	8176	134.7	1
Ribes cereum	1.8	20	538	24.0	3
Symphoricarpos oreophilus	4.3	70	7531	106.1	2
TOTALS	17.3		16999		

Table XI–70 SHRUB LAYER SPECIES COMPOSITION FOR BUNCHGRASS COMMUNITY
(Stand #20)
(VALUES BASED ON 20, 6' X 50' SHRUB TRANSECTS.)

SPECIES	COVER %	FREQUENCY %	#/HECTARE	IMPORTANCE VALUE	RANK
Artemisia tridentata	0.4	35	179	31.7	3
Atriplex confertifolia	4.9	85	1686	193.4	1
Atriplex canescens	0.4	20	448	33.8	2
Ceratoides lanata	0.2	10	72	10.7	5
Chrysothamnus nauseosus	0.0	5	18	3.4	7
C. viscidiflorus	0.1	20	161	18.6	4
Opuntia polyacantha	0.0	5	54	4.7	6
Sarcobatus vermiculatus	0.0	5	18	3.4	8
TOTALS	6.0		2636		

Current Land Use and Management. The Douglas-fir forests are grazed by cattle, but utilization in these areas is low because of the relative sparseness of the vegetation and also the steepness of the slopes. The number of trees is too low to support any lumbering in the area. These areas have not been managed either for tree production or for increased forage production.

e. Mixed Mountain Shrublands

General Location and Distribution. Mixed mountain shrublands represent some of the most widespread and abundant plant communities in the Piceance Creek basin, and are composed of numerous shrub species which are very important for supporting local mule deer populations. Because there are many shrub species which occur as dominants, the structure and composition of this vegetation type varies considerably depending on the slope, exposure, soil conditions and moisture regime. The most typical stands of mixed mountain shrub include serviceberry (*Amelanchier alnifolia* and *Amelanchier utahensis*), Gambel's oak (*Quercus gambelli*), snowberry (*Symphoricarpos oreophilus*), bitterbrush (*Purshia tridentata*), and mountain mahogany (*Cercocarpus montanus*). On some sites big sagebrush (*Artemisia tridentata*) also plays a dominant role in the vegetation. In addition to these common species, numerous other shrubs may occur to a lesser extent. Gooseberry and currant (*Ribes* spp.), squaw apple (*Peraphyllum ramosissimum*), mountain lover (*Pachystima myrsinites*), Oregon grape (*Mahonia repens*), chokecherry, and skunkbush (*Rhus trilobata*) are all species which fall in this category. Even though typical stands of mixed shrub include many species, there are sites on which communities dominated by a single species develop. Gambel's oak commonly occurs in nearly pure stands and is known locally as oakbrush. Mountain mahogany also occurs as an overwhelmingly dominant species on steep slopes which are relatively dry. In some places, serviceberry and big sagebrush occur together as community dominants. The most diverse types of mixed shrublands tend to be located on steep north-facing slopes and usually occur at lower elevations or on more exposed sites than either aspen woodlands or Douglas-fir forests. Shrub dominated communities, however, are not restricted to these steep slopes and commonly they occur in some form on ridgetops and southerly-facing slopes at higher elevations. There seems to be a very well-pronounced relationship between the compositional character of the mixed shrub community and the topographic feature on which it develops. The mixed mountain shrub communities on the Tract study area are limited in distribution and occur mostly on northerly-facing slopes.

Structure and Composition. The mixed shrub communities are composed of numerous shrub species (Gambel's oak, serviceberry, mountain mahogany, chokecherry, juneberry, snowberry, and Oregon grape), which comprise typical stands of mixed mountain shrublands. The communities show stratification even among shrub species. The vegetation canopy is composed primarily of larger shrub species (Gambel's oak, serviceberry,

and mountain mahogany). However, in some places snowberry forms a nearly continuous layer in the understory.

Herb species composition is varied and includes numerous species characteristic of more mesic vegetation types (Watson's beardtongue, fairy candelabra, pasque flower, sugar bowls, and elk sedge). Low growing shrub species like mountain lover and Oregon grape are also common in the herb layer.

In addition to the larger stands of mixed shrublands, small pockets of this vegetation type occur in the numerous gulches which are common on Tract. These areas are varied in composition. In many locations small groves of Gambel's oak occur at the upper ends of the lateral gulches which feed into the major drainages of the Tract. At other sites, patches of chokecherry occur in these gulches. Many species characteristic of the mixed shrublands occur along the intermittent stream channels forming miniature isolated patches of mixed shrublands. Even though these areas are small, they provide important habitats for wildlife species.

A somewhat different form of mixed shrubland occurs on the ridge immediately west of Little Scandard Gulch (Figure XI-27). In this community, sagebrush, serviceberry, and bitterbrush occur as dominant species. This form of mixed shrubland is more common at higher elevations, especially on the ridgetops. In many ways it represents a transitional type between upland sagebrush and typical mixed mountain shrub.

Stability, Diversity and Succession. The mixed shrub communities in their typical form represent stable communities unlikely to change as a result of succession. The large number of shrub species which characterize this vegetation type provide an element of stability lacking in low diversity shrub communities. The relationship between diversity and stability has received considerable attention in recent ecological publications and both supporting and refuting articles can be found. In the case of the mixed shrublands on the Tract, the diversity of shrub species could be very important, especially if one of the dominant species was found to be intolerant of industrial development. Where diversity is higher, a greater resiliency potentially exists.

Environment. The environmental characteristics in the mixed shrub communities provide some of the most favorable conditions for plant growth within the study area. The soils are mostly of the Redcreek-Rentsac type, but these appear to have been locally modified by the vegetation and are therefore considerably different than these same soil types developed in pinyon-juniper woodlands. Snow has a tendency to collect on these sites, and slow melting in the spring allows good percolation. Because of the north-facing slope aspect, soil moisture remains at high levels throughout the growing season (Table XI-45).

Better moisture conditions promote increased production which eventually results in higher soil organic matter content.

Fire does not seem to be an important factor in these communities. Some evidence of fire has been noted, but it does not appear to play an important role in determining the distribution of the mixed shrublands.

Current Land Use and Management. The mixed shrublands are currently used as livestock grazing areas during the summer months. No management practices have been employed in these communities.

f. Bunchgrass Community

General Location and Distribution. The bunchgrass communities occur primarily on steep talus deposits on the sides of the major valleys. Topographically they occupy intermediate positions between pinyon-juniper woodlands (located above the talus slopes) and bottomland sagebrush, greasewood, or agricultural areas (located below the talus slopes). Bunchgrass communities also occur on the burned pinyon-juniper sites on the Tract. These sites tend to be relatively level; however, other environmental conditions make them similar to the talus slopes (e.g., solar radiation, soil moisture). The best-developed bunchgrass communities on steep slopes occur near the existing main entrance to the Tract (P-L Ranch) along Piceance Creek. In West Fork Stewart Gulch, these communities occur as narrow bands between the bottomland sagebrush and pinyon-juniper woodlands.

Structure and Composition. The shrub layer in the bunchgrass communities is poorly developed and total density is approximately 2600 shrubs per hectare (Table XI-70). Along Piceance Creek (Stand 20) the predominant shrub species are shadscale (*Atriplex confertifolia*) and fourwing saltbush (*Atriplex canescens*). It is interesting that saltbush occurs on these sites, and its presence suggests above-normal salt concentrations in the soil. High salt concentrations characterize the alluvial fan deposits which occur immediately below Stand 20. It is possible that the determining factors causing the saline conditions in those communities may also be influencing the talus deposits. The specifics of these factors are not yet determined.

Herb layer cover in the bunchgrass communities averages approximately 30%. The dominant herb species in these communities is Indian ricegrass (*Oryzopsis hymenoides*), with a 90% frequency. This species is widespread throughout the Tract area, but it reaches its maximum development in these communities. Other common herb layer species include wild buckwheat (*Eriogonum lonchophylhum*), cheatgrass, and brickelbrush (*Brickellia grandiflora*). In the ground layer, 55% of the area is covered by bare soil and rock; accumulated plant litter provides only 35% cover (Table XI-41).

Stability, Diversity and Succession. The bunchgrass communities which occur on the talus slopes represent ecologically stable communities which are unlikely to be replaced by any other vegetation type. The species which grow on these sites are adapted to the extreme environmental characteristics and unstable soil conditions. Species diversity in these communities is low and averaged only 5.5 species per square meter.

The bunchgrass communities developed in burned-over areas are successional, and will eventually be replaced by pinyon-juniper woodlands or upland sagebrush communities.

Environment. The steep talus slopes where the bunchgrass communities occur present some of the most severe environmental conditions in the area. Many of these communities have south-facing exposures which tend to be warm in the winter and hot in the summer. The sparse bunchgrass cover allows penetration of solar radiation to the soil surface during the day and also allows substantial re-radiation of long wave radiation during the night, thereby causing considerable daily temperature fluctuations. The coarse soils have poor water retaining properties which, along with high growing season temperatures tends to increase evaporative losses. These communities occur mostly on Rentsac channery and Rentsac-Redcreek soils (Figures XI-27 and XII-1). These are mostly light-to-medium-textured soils with sufficient nutrient levels except for phosphorus and potassium which may be present in low or deficient amounts (Table XII-1).

The bunchgrass communities are mostly snow-free in winter since the south-facing slopes melt free of snow in a few days. Fire does not play a significant role in the bunchgrass communities which occur on the talus slopes. However Indian ricegrass does respond favorably to burning, and on some sites in burned pinyon-juniper woodlands it assumes dominance under post-fire conditions.

Current Land Use and Management. The bunchgrass communities are currently used for livestock grazing. Utilization is mostly restricted to late fall or early winter periods. Sparseness of the vegetation, limited areal extent, and the steepness of the slopes make these areas less important to livestock than the areas containing more widespread native vegetation types. These communities are currently not being managed for forage production.

g. Marshes

General Locations and Distribution. In this semiarid region of western Colorado, aquatic environments are very limited in extent, especially at elevations below 7000 feet. The most commonly encountered water bodies in the area are small reservoirs created either for stockwatering or irrigation purposes. In places where the water supply is

constant and standing water is shallow, marshes have developed. These communities are regionally uncommon and occur only on floodplains of major drainages. Within the Tract study area, several small marshes occur. However, none occur within the Tract boundary. Two large marshes (10 and 13 acres) occur along Piceance Creek approximately 2 and 4 miles upstream from the main entrance to the Tract. A third, smaller marsh (5 acres) occurs along Willow Creek, approximately 2-1/4 miles upstream from its point of confluence with Piceance Creek.

Structure and Composition. The vegetation in the marshes is composed primarily of perennial herbaceous aquatic and semi-aquatic plants. A few willows occur, but these are small and inconspicuous. The dominant species include cattail (*Typha latifolia*), common reed (*Phragmites australis*), and numerous species of sedges (*Carex* spp.) and rushes (Juncus spp.).

Stability, Diversity and Succession. The dominant species which occur in the marshes are adapted to the saturated soil conditions characteristic of these areas. As long as the environmental conditions remain wet, the marshes will continue to persist with few noticeable changes in vegetation structure. If, however, the sites were to dry out, the marshes would be replaced by a more mesic vegetation type such as a sedge meadow. The dominant aquatic species characteristically become rapidly established in uncolonized wet areas. Cattails, especially, have small, light wind-blown seeds which are produced in abundance. Because of the rapidity with which these communities become established and well-developed, it is difficult to determine how long the marshes have dominated the sites within the study area. It is possible that these marshes have developed since settlement times as a result of ponding of overland flow irrigation waters. If the sites have always been water collection areas, then the marshes are much older.

Environment. Because of the standing water, the environmental conditions in the marshes are considerably different from those in surrounding areas. Soils are continually saturated, and because of the great amount of unutilized production, soil organic matter concentrations are high. Other factors, such as precipitation, atmospheric moisture, and wind, which are important factors in surrounding communities, are relatively unimportant in the marshes.

Current Land Use and Management. The marshes along Piceance Creek occur in non-fenced areas adjacent to agricultural meadows and pastures. Consequently,these areas are highly utilized by cattle during the winter months when livestock are kept in these lower valley meadows. Much of the marsh vegetation is consumed annually or trampled by the grazing livestock.

h. Riparian Communities

General Location and Distribution. The riparian communities are located along the sides of the major streams in the area. Within the study area, the best developed riparian areas are along Piceance Creek, Willow Creek and the lower portions of Stewart Creek. Within the Tract boundary there are no riparian areas.

Structure and Composition. The vegetation along the streams is composed of sedges, rushes, horsetails (*Equisetum* spp.) and species of grasses (*Agrostis alba*, *Phleum pratense*, *Beckmannia syzigachne*). Other streamside species include marsh elder (*Iva xanthifolia*), checker mallow (*Sidalcea neomexicana*), nettle (*Urtica dioica*), Nuttall's sunflower (*Helianthus nuttallii*), and Canada goldenrod (*Solidago canadensis*). Willows (*Salix* spp.) occur to a limited extent; most of the individuals are small and isolated. The riparian vegetation is mostly restricted to stream trenches except in those areas where the banks slope gently to the stream bed. The riparian communities along Piceance Creek are bordered by large meadows. The separation of the meadows and riparian communities are indistinct and many semiaquatic species occur in the moist agricultural meadows. In other streamside areas, the riparian communities exist as narrow bands immediately adjacent to the streams.

Stability, Diversity and Succession. The riparian vegetation constitutes a stable community maintained by relatively constant stream flow. The species composition in these communities is relatively constant; variation from site to site is low. In many places the streamside vegetation has been altered because of irrigation practices. Recovery from disturbance is rapid, primarily because of the favorable moisture conditions associated with these communities. Construction of irrigation ditches has done much to increase the extent of this vegetation type, since the environmental conditions along the ditches are much the same as those along the streams.

Environment. The environmental conditions along the stream are very favorable for plant growth. Moisture is present in abundant amounts, and in some cases saturated soil conditions may limit species diversity by allowing only aquatic species to grow. Soil nutrients are plentiful, and irrigation return flows enrich the naturally high nutrient levels.

Current Land Use and Management. The streamside communities are grazed by livestock, with utilization concentrated mostly in the winter months. Most of the grasses, forbs and some of the smaller willows are annually consumed by the cattle. The livestock also affect the vegetation by trampling, which can be substantial especially in the soft, wet soils.

i. Great Basin Wild Rye Communities

General Location and Distribution. After the arrival of the first ranchers in the Piceance Creek basin region, reports of grasses taller than a horse and rider filtered back into the early settlements. This grass was Great Basin wild rye (*Elymus cinereus*) which prior to settlement had occured in dense stands on the floodplains of larger streams. Many of the areas formerly dominated by Great Basin wild rye have been converted into agricultural meadows and pastures, and only a few areas of this vegetation type remain. The valley floors of the major streams consist of three different land forms: alluvial fans, floodplains, and stream channels or trenches. These land forms each support different vegetation types. However, these types intergrade and overlap slightly.

Depending on soil salt concentration, the alluvial fans support either big sagebrush (intermediate salt levels) or greasewood (higher salt concentrations). The stream trenches support narrow bands of lush semi-aquatic vegetation, and the flat floodplains originally supported Great Basin wild rye communities. Remnants of this original pattern of vegetation along areas like Piceance Creek can still be found along the upper reaches of the stream about four miles west of the Rio Blanco store.

On the Tract study area, stands of Great Basin wild rye are restricted to small floodplain areas along Willow Creek and East Fork Stewart Gulch. These locations likely have never been plowed or improved for irrigation, and for these reasons the wild rye has persisted.

Structure and Composition. The dominant species in these communities is Great Basin wild rye, which occurs as tall, robust clumps. This species is non-rhizomatous and consequently it does not produce a continuous cover. However, where the large clumps occur, the cover is dense. Other common species include cheatgrass and mountain peppergrass. Few shrubs occur in these communities, but big sagebrush plants are occasionally encountered.

Stability, Diversity and Succession. If undisturbed, the Great Basin wild rye communities show considerable stability. Mention of their occurrence by early settlers and land surveyors indicates their presence as a community type in the late 1800's. The individual grass clumps appear to be long-lived, and reproduction and seedling establishment attest to the continued success of the dominant species. The original extent of these communities has been considerably reduced because of their location on arable floodplain sites. No successional changes have been noted in these communities, and they appear to be the ultimate plant community which naturally develops on the floodplain sites.

Environment. The Great Basin wild rye communities occur on medium textured alluvial soils, primarily of the Glendive loam type. These

soils are saline due to excessive amounts of sulfate and sodium. Great Basin wild rye is apparently adapted to these salty conditions, and is not elimited from saline sites until salt levels are considerably higher. The Glendive soils have high levels of nitrogen, phosphorus, and potassium, and of measured nutrients only zinc is deficient (Table XII-1).

Current Land Use and Management. The Great Basin wild rye communities are used as grazing areas mostly in the winter. The tall grasses are rather coarse and unpalatable, but they are utilized to some extent by cattle.

j. Rabbitbrush Communities

General Location and Distribution. In the Piceance Creek basin, two species of rabbitbrush are commonly encounted (*Chrysothamnus nauseous* and *Chrysothamnus viscidiflorus*). The latter is more common at higher elevations where it occurs as a sub-dominant species in upland sagebrush communities and mixed mountain shrublands. It very rarely attains large size or community dominance and does not occur in pure stands. Rubber rabbitbrush (*C. nauseous*) is a much more common species at lower elevations and rarely occurs in abundance in upland plant communities. It is frequently encountered in chained rangelands, but in these areas it does not assume community dominance. On floodplains and valley floors, this species occurs at high densities and forms communities in which few other shrub species occur. The distribution of this vegetation type in the Tract area is restricted to floodplain areas which have apparently been disturbed in some manner since settlement times. The best development of rabbitbrush occurs at the mouth of West Fork Stewart Gulch. Other small stands of this community type occur elsewhere in the Stewart Creek drainage and also in the upper portions of Willow Creek valley.

Structure and Composition. The shrub layer of the communities is dominated by rubber rabbitbrush which has an average cover of 43% and occurs at approximate densities of 11,000 shrubs per hectare (approximately equal to one shrub per square meter). The only other shrub species which occurs in those communities is big sagebrush (Table XI-71).

The herb layer is composed primarily of mountain peppergrass (100% frequency), western wheatgrass (95% frequency) and cheatgrass (95% frequency). In addition to these three species, numerous other weedy species occur (Tables XI-41 and XI-42, Stand 17). The herb layer species composition in these communities is very similar to that encountered in the valley sagebrush communities and suggests a relationship between these two types. Additionally, the presence of introduced annual weed species indicates grazing disturbances.

Stability, Diversity and Succession. Based on observations of vegetation patterns in bottomlands within the study area, it appears that the rabbitbrush communities constitute a successional vegetation

Table XI–71 SHRUB LAYER SPECIES COMPOSITION FOR RABBITBRUSH COMMUNITY
(Stand #17)
(VALUES BASED ON 20, 6 X 50 SHRUB TRANSECTS.)

SPECIES	COVER %	FREQUENCY %	#/HECTARE	IMPORTANCE VALUE	RANK
Artemisia tridentata	0.3	31.58	452	28.6	2
Chrysothamnus nauseosus	43.2	100.00	10910	271.4	1
TOTALS	43.5		11362		

Table XI–72 SHRUB LAYER SPECIES COMPOSITION FOR GREASEWOOD COMMUNITY
(Stand #18)
(VALUES BASED ON 20, 6' X 50' SHRUB TRANSECTS

SPECIES	COVER %	FREQUENCY %	#/HECTARE	IMPORTANCE VALUE	RANK
Artemisia tridentata	.1	10	356.	7.2	3
Atriplex canescens	0.3	5	18.	4.5	4
Chrysothamnus nauseosus	3.2	40	699.	46.9	2
Sarcobatus vermiculatus	27.1	100	5918.	242.7	1
TOTALS	30.7		6671		

type rather than a stable community. In some areas, boundaries of rabbitbrush communities are defined by livestock fences, suggesting the development of this type in response to agricultural activities. The rabbitbrush appears to be developed on sites which were previously covered by valley sagebrush communities.

Successional changes may be expected in the rabbitbrush communities, if current grazing practices are continued. It is possible, however, that the disturbances which allowed the development of the rabbitbrush caused significant enough changes that valley sagebrush communities may not recover on these sites, even if grazing were to be discontinued.

Environment. Environmental conditions in the rabbitbrush communities are very similar to those in the valley sagebrush sites. Both of these communities occur on Glendive soils, which contain excessive amounts of sodium and sulfate. Soil moisture averaged about 25% during the growing season (June-August), which is a surprisingly low value for a valley site. However, it is consistent with other valley soil moisture values. Soil nutrients are present in normal or above-normal amounts, and zinc is the only nutrient which exhibts a deficiency.

Fire may play a role in the establishment of rabbitbrush communities. Sagebrush is intolerant of fire, and it may be possible that rabbitbrush recovers more quickly on burned sites.

Current Land Use and Management. The rabbitbrush communities are used for livestock grazing, but they are not managed for range improvement.

k. Greasewood Communities

General Location and Distribution. Throughout western Colorado, greasewood communities characteristically occur on alluvial deposits which usually contain high concentrations of soil salts. Extensive areas of greasewood and saltbush occur in the cold salt desert regions of northwestern Colorado. The overall range of this community extends into the Piceance Creek basin region, but here, it is restricted to valley bottoms and alluvial fans where local salt levels are high. In the Tract study area, greasewood communities are restricted to alluvial fans along Piceance Creek. Isolated individuals occur elsewhere on the Tract, but greasewood community development is restricted to these sites.

Structure and Composition. The species composition in the greasewood communities strongly reflects the intensive grazing utilization which they receive. The greasewood stands are located on the fenced portions of the Piceance Creek floodplain where livestock are wintered. Heavy grazing and trampling cause continued disturbances which provide favorable conditions for the growth of weedy species.

The dominant species in these communities is greasewood (Sarcobatus vermiculatus) which provides an average cover of 27% and occurs at a density of approximately 5900 individuals per hectare (Table XI-72). The shrub layer is relatively open and the individual shrubs tend to grow in clumps rather than form a continuous canopy. Rabbitbrush (Chrysothamnus nauseousus) occurs as a secondary dominant species, but it is far less abundant than is greasewood.

The herb layer is composed of relatively few species which most likely resulted from disturbance and high soil salt concentrations. The most common herb species are crested wheatgrass (Agropyron cristatum) and cheatgrass, both of which are introduced species. The crested wheatgrass was probably seeded into this area in order to provide more forage for cattle. Total herb cover was about 43% and was mostly provided by the two dominant species.

Stability, Diversity and Succession. The greasewood communities constitute an ecologically stable vegetation type in the Tract study area. The environmental conditions under which these communities grow are such that few other species can successfully compete with the community dominants. Even though herb diversity is very low (3 to 4 species per square meter), these communities demonstrate considerable resiliency and tolerance of continued heavy utilization and disturbance. The stands of greasewood which occur within the area have most likely been growing on these sites since pre-settlement days. Individual plants have matured and died during this time interval, but the basic appearance of these communities has most likely not been altered.

Environment. The greasewood communities occur on Hanly loam soils which are medium-textured, basic and characterized by excessive amounts of nitrates, sulfates, and sodium (Table XII-1). Excessive levels of these nutrients are deleterious to plant growth and only certain species have adapted to grow under these conditions. The high salt levels are most likely caused by storm runoff which tends to moisten only the upper four to six inches of soil. Water amounts are insufficient for deep percolation, thus causing salts to concentrate in the upper soil levels as the moisture evaporates from the surface and carry the salts upward to the surface by capillary action. Greasewood plants are phreatophytic, which means they tap the water supply at the capillary fringe of the ground water table. By being tolerant of the salty conditions, these plants are assured of a continuous water supply throughout the growing season. Surface salt concentrations may also be increased by leaching of the litter (dead leaves and twigs) which fall from the greasewood plants.

Other environmental factors appear to be less important in the growth of the communities. Soil moisture is important for the herbaceous species and tends to be sufficient early in the growing season.

The species in the greasewood communities are intolerant of fire so that when fires occasionally occur they cause considerable damage. No evidence of fire in the greasewood communities has been noted within the Tract areas.

Current Land Use and Management. The greasewood communities are used as grazing areas during the winter months. In addition to providing limited forage, the tall shrubs also provide some protection from winter winds. The presence of crested wheatgrass in these communities suggests some range improvement seeding, however these communities are not managed for range improvement.

1. Agricultural Meadows

The agricultural meadows in the Tract area are restricted to floodplain areas along the major streams. These communities are composed primarily of alfalfa and introduced pasture grasses. The areas are used for hay production during the summer months when cattle are kept on native summer rangelands. During winter months, the agricultural meadows are used as grazing areas.

The primary non-industrial occupation within the Tract study area is cattle ranging. The agricultural meadows form an important link in total nutrient cycling and energy flow in the livestock-vegetation system (Figure XI-33). Irrigation waters from Piceance Creek are used to increase hay production in the floodplain meadows. Usually only a single cutting of hay is produced and stacked for winter feeding to cattle. Regrowth of hay species is left standing in the fields and is utilized by livestock when they are returned to the lower valleys for the winter. Limited areas of native vegetation (marshes, riparian communities, greasewood and sagebrush communities) which occur on the floodplain pasture areas are also utilized by cattle during the winter months. Little, if any, of the hay crop is exported from the system. Most of the year's production is used to sustain cattle herds through the winter months. Nutrients and unassimilated materials are therefore retained in the system in the form of cow dung. The final products of the system are marketed cattle. Individuals lost to natural causes return to the system via decomposition. Energy losses in the form of heat or respiration characterize all energy conversion reactions.

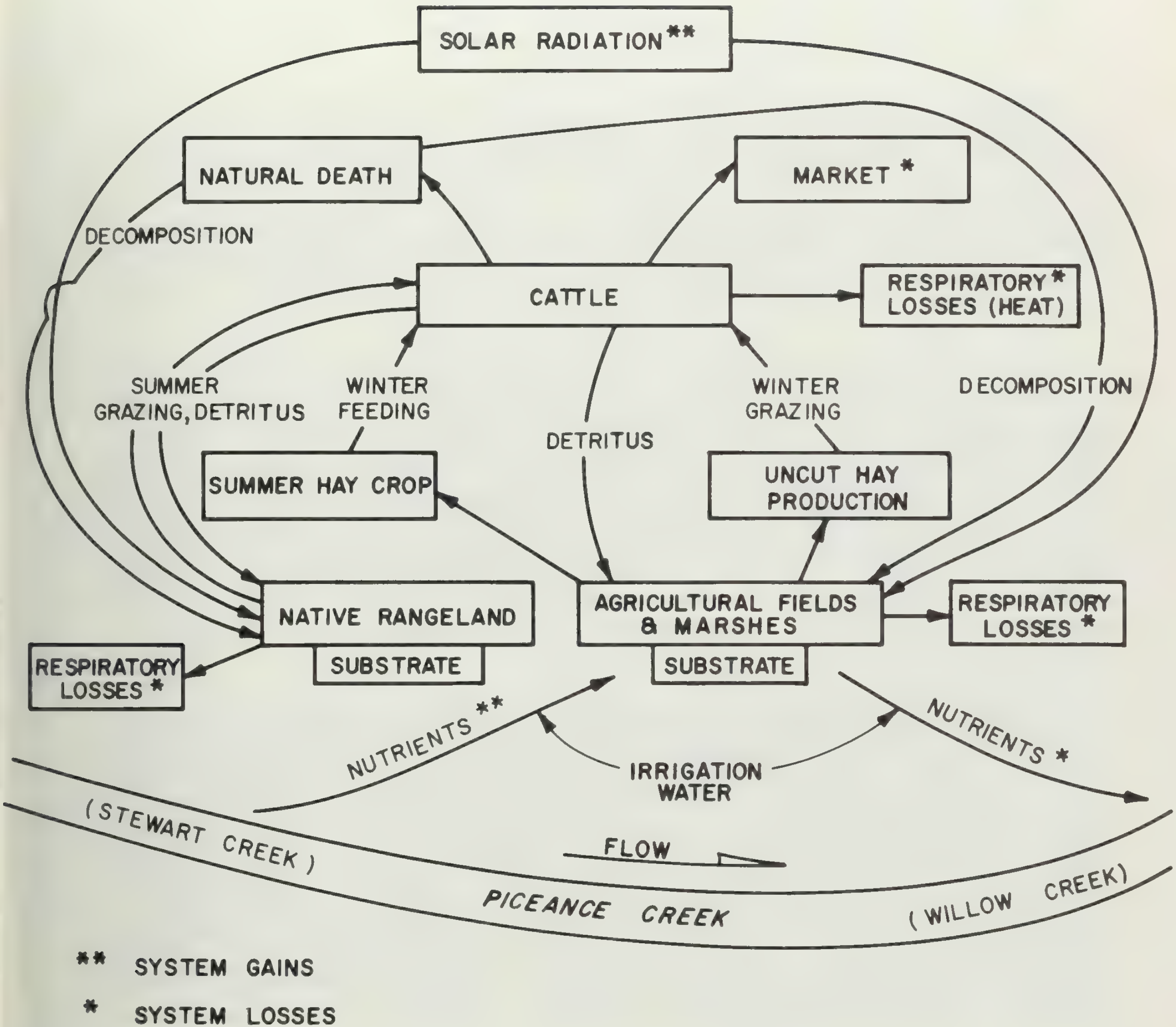


Figure XI-33 FLOW OF ENERGY THROUGH LIVESTOCK-VEGETATION SYSTEM

During the summer, cattle graze on native vegetation at higher elevations, where energy flow and nutrient cycling follow patterns characteristic of natural systems. The cattle are dependent on native grass and forb production, and recycle nutrients through elimination of non-utilized materials and through death and decomposition.

m. Annual Weed Communities

General Location and Distribution. The annual weed communities comprise a somewhat artificial vegetation type which develops on disturbed sites. Disturbances stem from recent industrial development activities (well drilling platforms and access roads), and ranching activities (stock holding and ranchyard areas). Location of these areas follows no pattern, and as might be expected, the appearance of the vegetation which develops on disturbed sites varies considerably from site to site.

Structure and Composition. The vegetation on the disturbed sites is composed primarily of annual weeds. On some sites perennial grasses have become established, but they currently occur in limited amounts. Shrubs are generally lacking from any of the disturbed sites; however, an occasional individual may be encountered. Dominant species on these sites include annuals such as cheatgrass, white pigweed (*Amaranthus albidus*), tumble mustard, Russian thistle (*Salsola kali*) and goosefoot (*Chenopodium album*). Western wheatgrass and Indian ricegrass are the most commonly encountered perennial grasses. A total of 39 species was encountered in sampling the disturbed sites (Tables XI-41 and XI-42, Stands 22-28).

Stability, Diversity and Succession. The annual weed communities represent the first successional vegetation stages which develop on disturbed sites. In this regard the communities are ecologically unstable and are changing in the direction of equilibrium vegetation types. The final vegetation type which will eventually occupy these sites is primarily determined by the surrounding vegetation. Disturbed sites in the valleys will most likely support sagebrush communities, while upland sites will probably develop as pinyon-juniper woodlands. The transition back to stable communities will require a long period of time. Re-establishment of pinyon-juniper woodlands may take as long as 200 years. Because of reduced complexity, shrublands may require only 60 to 70 years to reach stable conditions.

Diversity on the disturbed sites was low and averaged only 4.2 species per square meter in the sampled stands.

Environment. Environmental conditions in the annual weed communities are harsh and not conducive to plant growth. Soil characteristics have been altered by disturbance and on some sites coarse subsurface materials have been brought to the surface. Soil surface temperatures fluctuate daily over wide extremes owing primarily to a poorly developed vegetation canopy and lack of plant litter. Soil organic matter content is low, but will increase as the successional sequence progresses.

Current Land Use and Management. Cattle utilize these areas incidentally as they graze throughout the native vegetation communities.

Management has been limited to reclamation and revegetation of some of the sites.

4. Aquatic Plant Communities

a. Lotic

Ponds and lakes are forms of lotic communities. In the ponds near the Tract, organic content is high and the bottoms of the ponds are covered with a fine sedimentary ooze. Pondweeds (*Potomogeton* spp.) are found in most of the ponds. Because the ponds are maintained by ranchers, they have not gone through the successional stages as quickly as might be expected.

b. Lentic

Rivers, streams, seeps and springs are all forms of Lentic communities. Piceance Creek supports local concentrations of watercress (*Rorippa* spp.)which is one of the commonly encountered species in the stream. Throughout most of the year, Piceance Creek shows many of the characteristics of an old river; that is, it meanders on the valley floor. However, in the spring, snow runoff swells the stream and increases the silt loading. Cold water temperatures and the high turbidity tend to retard the growth of plants and algae. By late summer, however, with clean water and warmer temperatures, plants have recovered and growth is luxuriant.

D. Ecosystem Interrelationships

Ecological relationships exist between organisms, and between the organism and its environment. The non-living, or abiotic environment provides the background in which the living, or biotic environment (plants, animals, bacteria, etc.) interact in an energy-dependent manner. This combination of air, water, temperature, plants, animals, etc. is collectively known as an ecosystem, and has been conceptually defined to provide an understanding of how groups of organisms are organized and function.

The energy provided to the system comes from solar radiation. Sunlight is the only significant source of energy in most ecosystems and is utilized by the vegetation during photosynthesis. During photosynthesis carbon dioxide is assimilated into energy-rich carbon compounds. Plants, which perform this function, are known collectively as producers.

Many animal groups exist which derive their nutritional requirements from feeding on plant material; roots, leaves, flowers, seeds, etc. These animals are collectively known as primary consumers, or herbivores. Herbivores may be cattle, deer, ground squirrels, or even sap-sucking plant bugs.

An organism which feeds on an herbivore is called a carnivore, secondary consumer, or predator. These organisms derive their energy indirectly from the producers by way of the herbivore.

A fourth category of organisms are collectively called decomposers and are mainly bacteria and fungi. Their primary role is that of the mineralization of plant and animal matter through enzymatic action, and making the resulting nutrients and minerals available for plant use.

Two basic processes are taking place in an ecosystem: 1) the one-way flow of energy from the sun through the producers to the consumers and decomposers, and 2) the continual cycling of nutrients through the entire system. Within these two processes a large array of plant-animal, and animal-animal interactions are taking place. These interactions are depicted in Figure XI-34 which shows a foodweb diagram for the Tract. The direction and relative size of the arrows show the principal routes of energy transfer within the system.

Several relationships have been addressed in the biological baseline studies of the Tract. These include the following: 1) Plant productivity and herbivores; 2) Predator-prey relationships; 3) Plant host relationships; 4) Parasite-host relationships; 5) Deer-cattle competition; 6) Plant-soil nutrients; 7) Wildlife-environment relationships; 8) Vegetation-environment relationships; and 9) Aquatic food web. These are discussed in the following subsections.

1. Plant Productivity and Herbivores

The two major herbivorous groups of mammals on the Tract are the

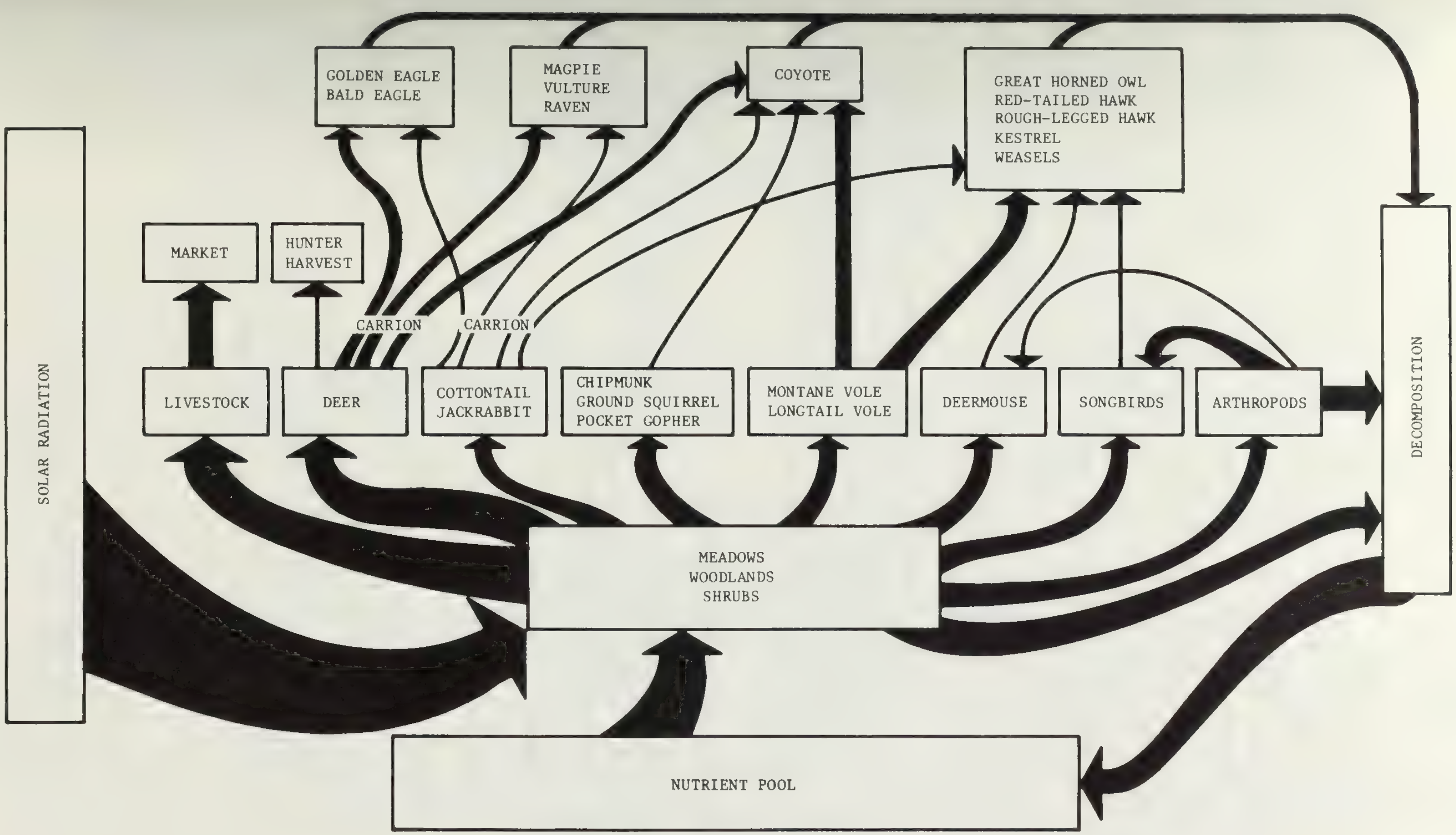


Figure XI-34 PRINCIPAL ROUTES OF ENERGY TRANSFER IN TRACT C-b STUDY AREA

mule deer and the small mammals. (The cattle are also a major herbivore group; they are discussed below in the section on deer-cattle competition.)

Deer occupy the Tract and the surrounding area from about mid-October through mid-May. During the winter, deer rely heavily on browse species to meet their nutritional requirements. The major browse species are big sagebrush, mountain mahogany, serviceberry and antelope bitterbrush. In the late fall and early spring the agricultural meadows along Piceance and Willow Creeks provide a substantial portion of their diet. Figures XI-35 through XI-38 show the major interactions involving mule deer in four habitats on the Tract. Rather than showing the energy in each level that is available to the next, the diagrams show numbers, biomass, or percentages. The actual energy involved at each level has not been determined. Data from surveys conducted during the first year of baseline studies are shown in these figures. In terms of deer utilization of the four major habitat types, the most heavily utilized native rangeland during the winter was the upland sagebrush vegetation, followed by the chained pinyon-juniper rangeland.

Three small mammal species (least chipmunk, deer mouse and montane vole) are important consumers of vegetation on the Tract. These first two species consume large amounts of insects and other arthropods. Figures XI-39 and XI-40 show the role of these major small mammalian species in the chained pinyon-juniper rangeland and in the pinyon-juniper woodland, respectively.

2. Predator-prey Relationships

The most common predator and prey species which have been identified on the Tract are listed below. Ravens, magpies and turkey vultures are primarily scavengers and are discussed separately.

Common Predators and Prey Species

Predators	Prey
Mammals:	Desert cottontail
	White-tailed jackrabbit
Coyote	Montane vole
Bobcat	Long-tailed vole
Badger	Deer mouse
Raccoon	Bushy-tailed woodrat
Striped skunk	Northern pocket gopher
Birds:	
Red-tailed hawk	
American kestrel	
Rough-legged hawk	
Great horned owl	
Marsh hawk	
Golden eagle	

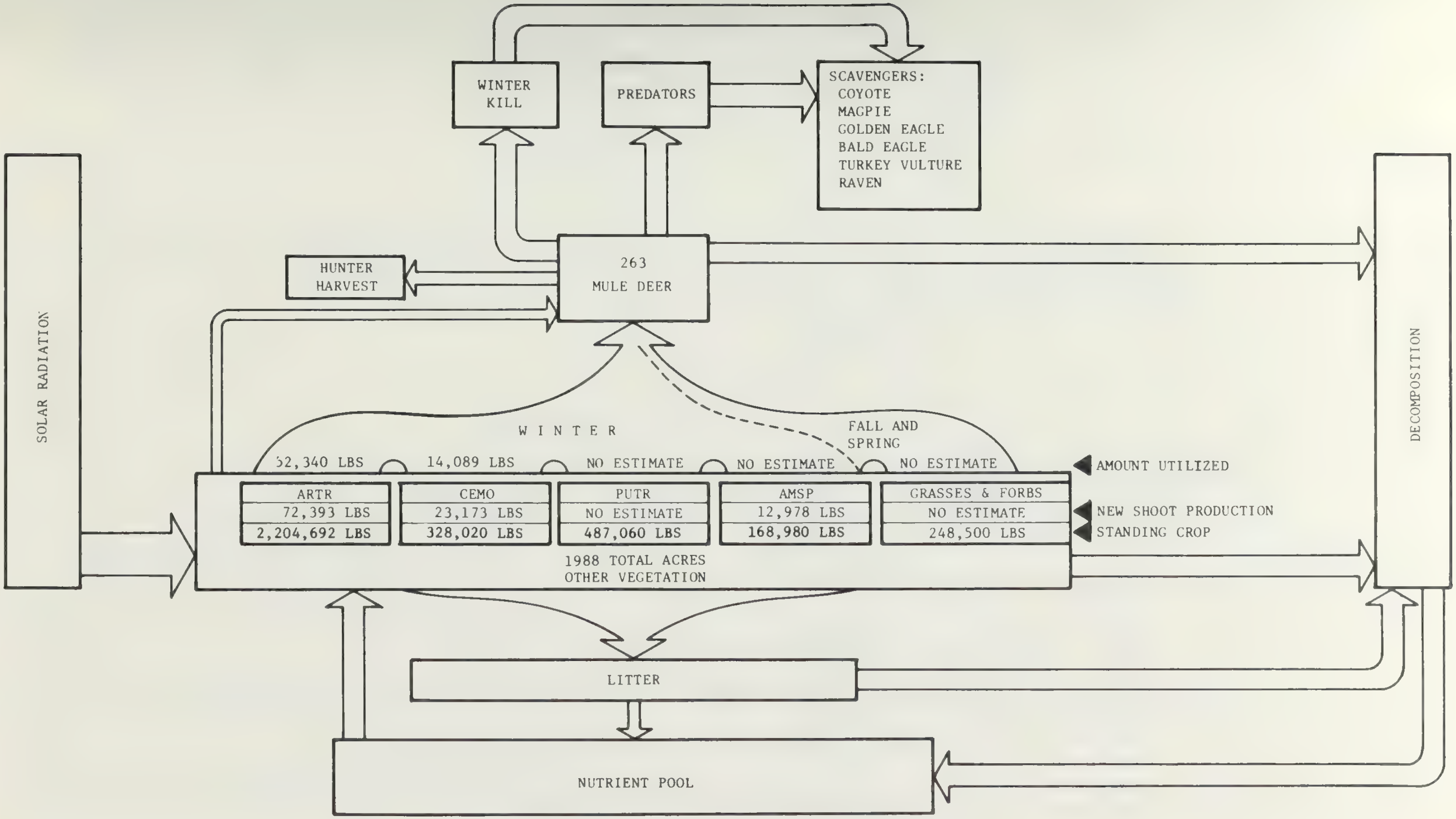


Figure XI-35 MAJOR INTERACTIONS INVOLVING MULE DEER IN THE CHAINED PINYON-JUNIPER RANGELAND HABITAT, TRACT C-b

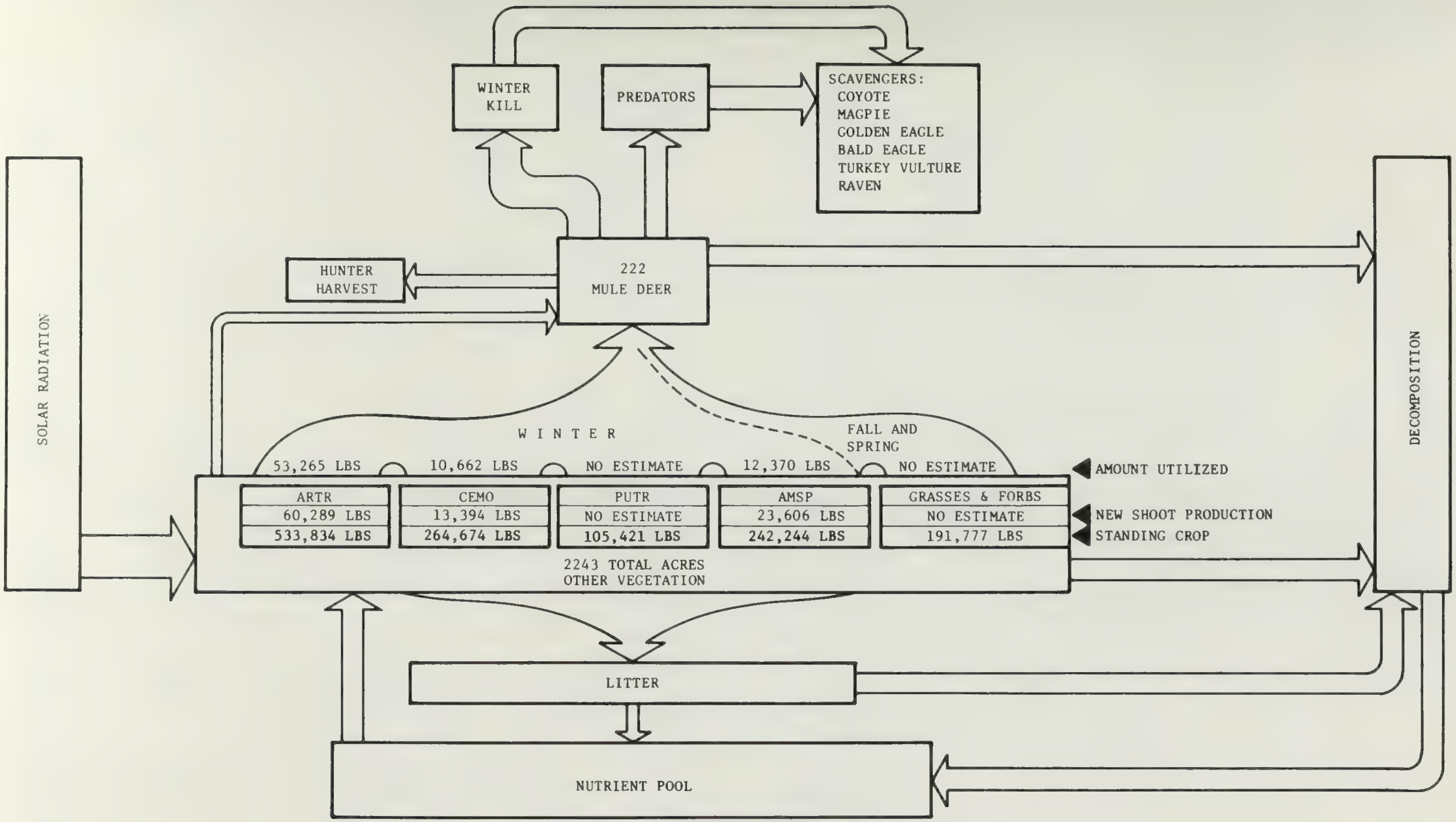


Figure XI-36 MAJOR INTERACTIONS INVOLVING MULE DEER IN THE PINYON-JUNIPER WOODLAND HABITAT, TRACT C-b

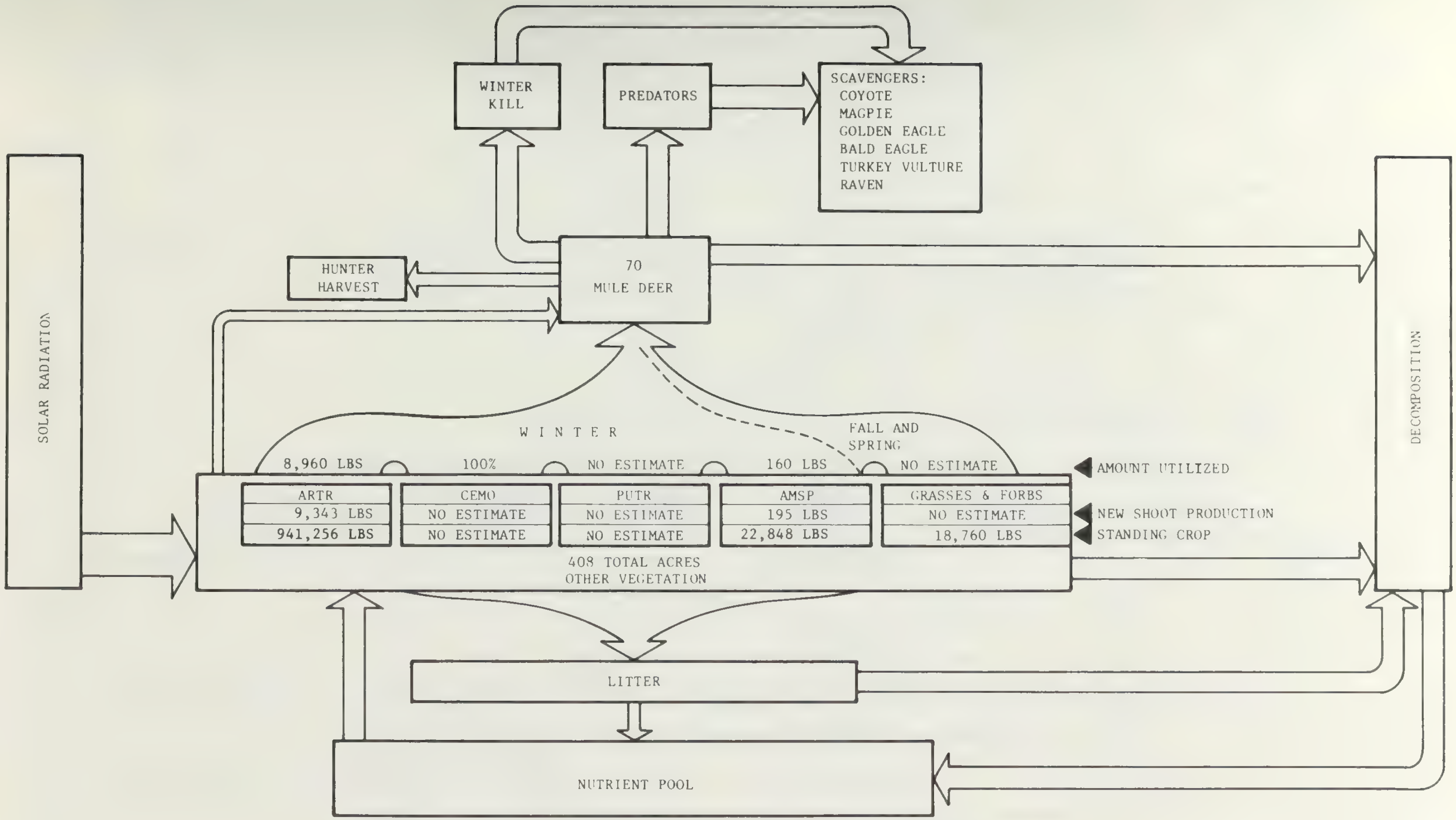


Figure XI-37 MAJOR INTERACTIONS INVOLVING MULE DEER IN THE UPLAND SAGEBRUSH HABITAT, TRACT C-b

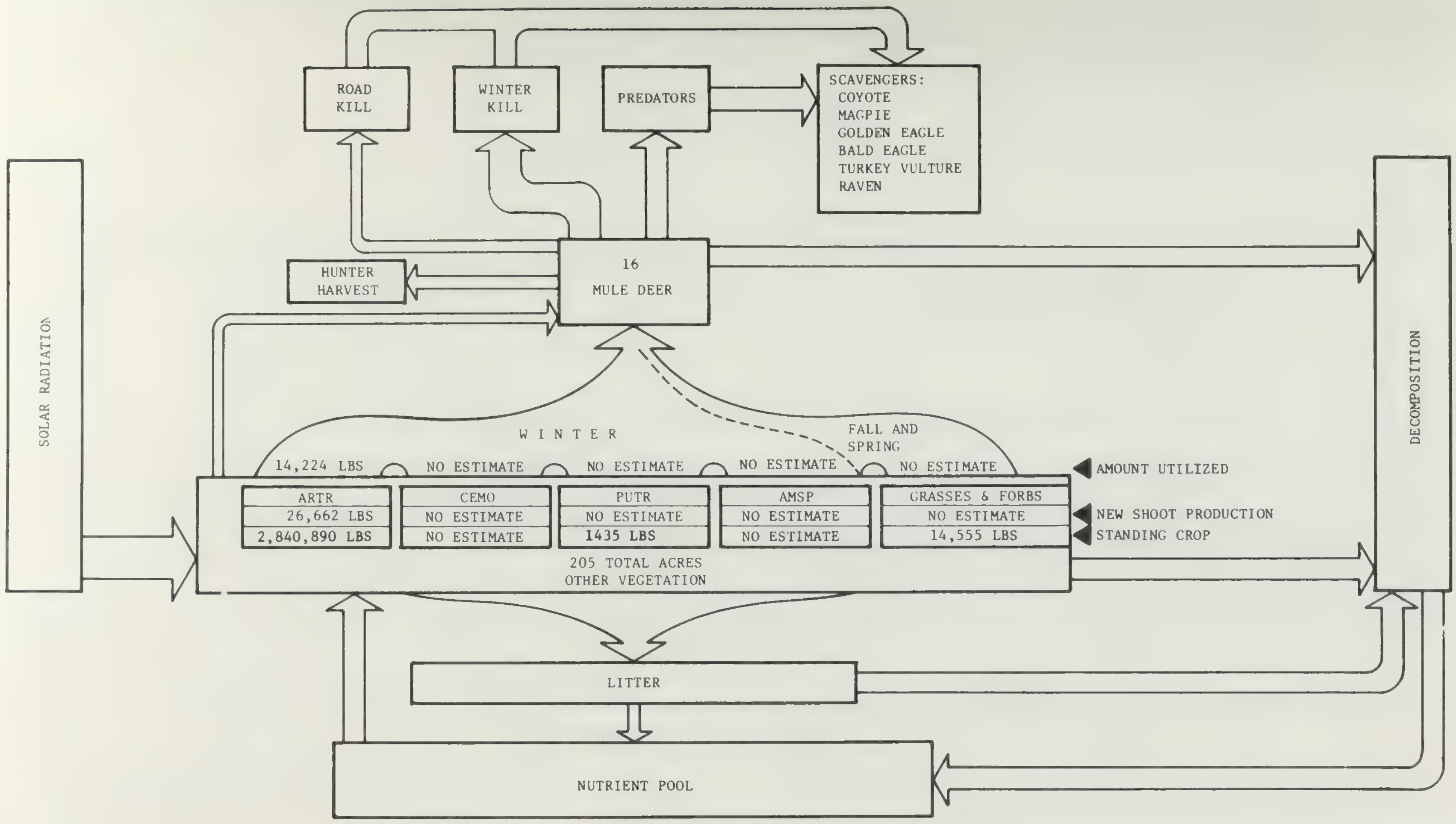


Figure XI-38 MAJOR INTERACTIONS INVOLVING MULE DEER IN THE VALLEY BOTTOM SAGEBRUSH HABITAT, TRACT C-b

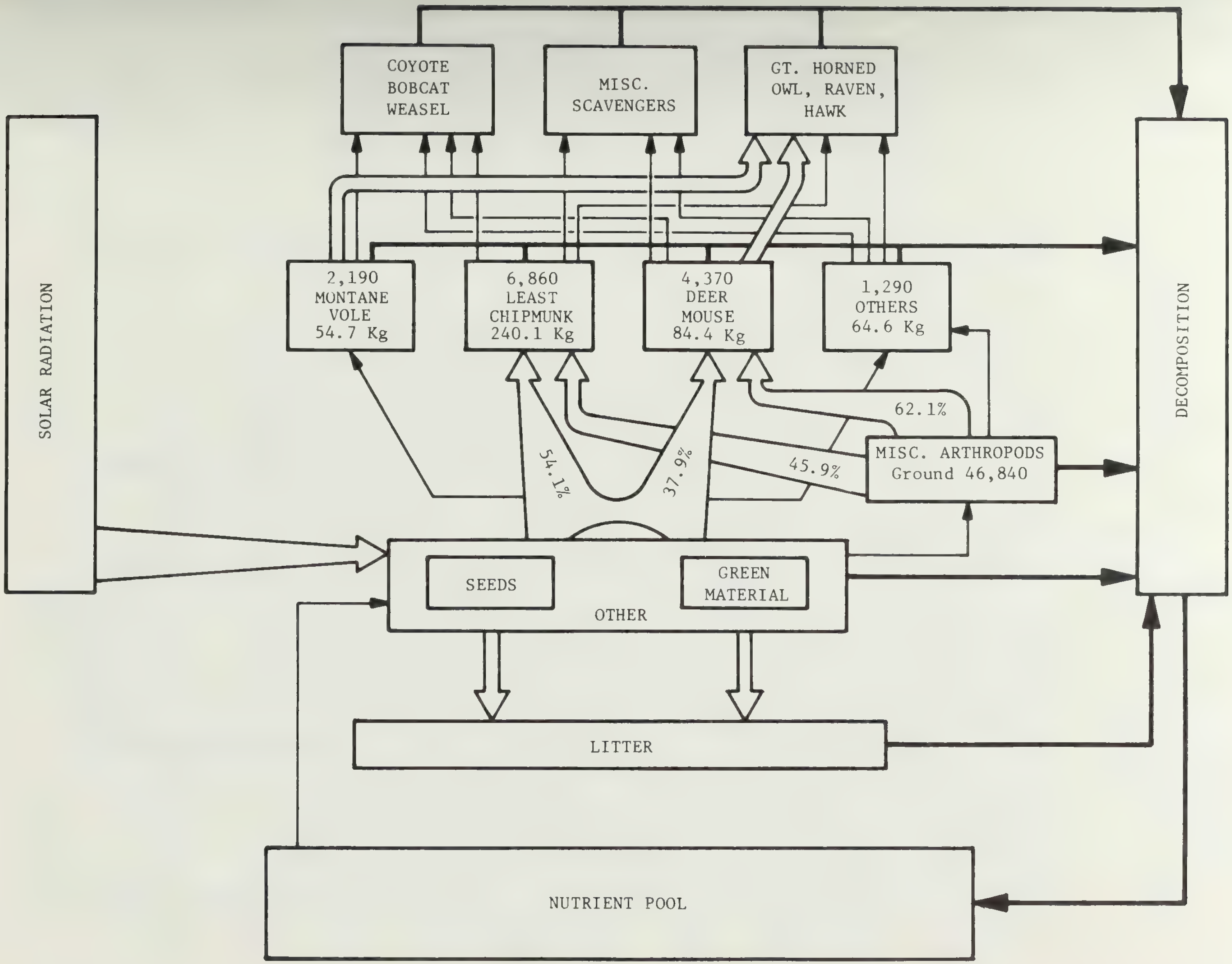


Figure XI-39 ROLE OF SELECTED SMALL MAMMAL SPECIES IN THE CHAINED PINYON-JUNIPER RANGELAND HABITAT, TRACT C-b

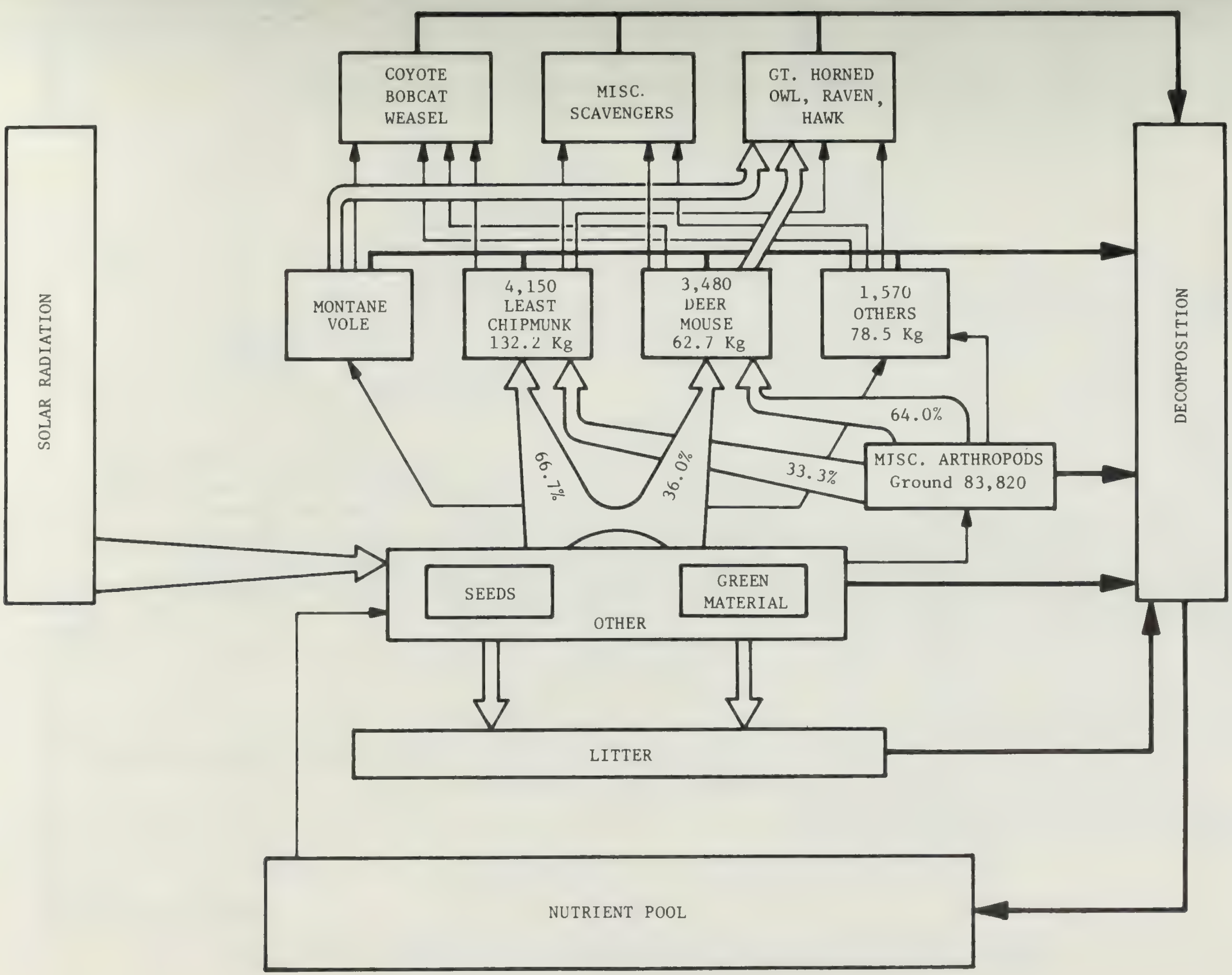


Figure XI-40 ROLE OF SELECTED SMALL MAMMAL SPECIES IN THE PINYON-JUNIPER WOODLAND HABITAT, TRACT C-b

In the Tract area, the main vertebrate predators and their most common prey have been identified, along with such related concerns as the respective habitats of each of these species and their general levels of abundance over the year. Some quantification has been achieved regarding raptorial food habits because of the relative ease with which raptor pellets (regurgitated casts of identifiable bones, hair, etc.) can be collected and examined. Otherwise, interpretations are based largely on field observations.

In terms of ecosystem functioning, predator-prey interactions involve population effects of both the predator and the prey, although the more commonly asked question concerns the magnitude to which a prey population is suppressed due to predation. In this discussion it will be more useful to examine the importance of the prey base in sustaining the existing predators. Emphasis, therefore, will center on the important prey species and the habitat types on the Tract that are necessary for maintenance of significant prey populations. During 1975, the prey population did not recover to levels attained in 1974. Voles are known to show dramatic fluctuations in population density which biologists have not been able to associate with specific causative agents. Their fluctuations undoubtedly influence the reproductive success of some raptorial birds and certain predatory mammals. Hence, the importance of the agricultural meadows along Piceance and Willow Creeks to the support of vole populations becomes ultimately tied to the maintenance of many predators in the area.

The predators that fed extensively on montane voles during 1974 (especially during the fall and winter when invertebrates, chipmunks and ground squirrels became inactive) included coyotes, great horned owls, rough-legged hawks and ravens. Table XI-73 summarizes results of pellet case examinations and indicates that voles comprised 80.4%, 90.8% and 86.7% of the diet of the great horned owl, rough-legged hawk and raven, respectively. For the owl and raven, these percentages are averages over winter, spring and summer periods. For rough-legged hawks which are present on the Tract only during winter, the percentage indicates relative vole consumption during the winter period. All these predators have generalized food habits and are likely to take prey species that are most numerous at the time. This is exemplified by the diet of great horned owls. Over 90% of the fall and early winter diet of great horned owls consisted of voles. When this prey supply declined during late winter and spring, the voles comprised approximately 50% of the diet, with deer mice and pocket gophers becoming important prey species.

The importance of the agricultural meadows to predators was most evident through field observations of rough-legged hawks and ravens which feed during the day. In the winter of 1974-75, rough-legged hawks were the most numerous raptor in the area. Field observations and pellet analyses demonstrated that this species relied almost exclusively on montane voles.

The long-tailed vole, similar to the montane vole, frequently cannot be distinguished from other voles in raptor pellet analyses. This vole was found to be an important prey species as well, but not as important as the montane vole. While more studies are needed regarding the ecology

Table XI–73 USE OF VOLES BY RAPTORS IN THE TRACT C-b STUDY AREA DURING WINTER, SPRING AND SUMMER, 1975.

Species	Total Pellets Analyzed	Total Number of Prey Items	% of Voles In Prey Items
Great horned owl	256	384	80.4
Rough-legged hawk	49	66	90.8
Raven	88	60	86.7

of the long-tailed vole, this species appears to occupy mainly the upland areas, and to be less abundant locally than the montane species.

The agricultural meadows can be singled out as one of the most important habitat types in the area in terms of sustaining predators. In addition to montane voles, prey species which utilize this habitat include many insects, songbirds and other small mammals. These species, in general, occur in many areas and are best considered as part of the total ecosystem.

Desert cottontails and white-tailed jackrabbits are important prey species in the Tract area, but the population levels of both are presently low. It appears, however, that both species are becoming more numerous, and if populations do increase significantly it is likely that golden eagles and red-tailed hawks will also become more numerous. The reproductive success of both of these raptors is often influenced by lagomorph abundance.

During late winter when fewer prey species are available to predators, both avian and mammalian predators tend to concentrate in areas having the largest food supplies. The Tract is of special interest in this regard since winter deer mortalities apparently occur here with greater frequency than in nearby areas of the Piceance Creek basin. Many of the larger predators on-tract rely on scavenging dead deer during the winter period, and in some cases predator kills occur. Two known cases of deer having been killed by coyotes have been reported, and one observation was made of a golden eagle attacking a fawn. Deer mortality studies have shown the small lateral draws that are oriented perpendicular to the main north-south drainages are areas where large numbers of deer die during winter. Field observations during the winter have relied heavily on sightings of ravens, magpies and golden eagles revealing the location of a recent winter-killed deer. Observations of these fresh carcasses have demonstrated the importance of this food source to bald eagles which occur only as winter visitors to the Tract area. During spring, turkey vultures are also attracted to these winter-killed deer and it is possible that the relatively high densities of both coyote and turkey vultures in the Tract area are due to the abundance of deer carrion.

3. Plant-Host Relationships

Arthropods on the Tract function as herbivores, insectivores and scavengers. There are several types of herbivore relationships present. Some arthropods, such as grasshoppers and leaf beetles, eat leaves and tender stems. Others, such as plant bugs, leafhoppers and aphids, feed by sucking plant juices from various parts of the plant. This feeding can result in discoloration, wilting, stunting or even death. Some, like wasps, attack plants in a way which causes galls to be formed. The majority of herbivores sampled on the Tract belong to the order Homoptera and are commonly collected from shrubs.

The relative abundance of arthropod populations was compared in the two major vegetation types and among three common shrubs found on the Tract. The relative abundance of arthropods was found not to vary significantly with the species of shrubs sampled by sweep netting. In the period May-July 1975, it appears that serviceberry (Amelanchier spp.), sagebrush (Artemisia tridentata) and mountain mahogany (Cercocarpus montanus) all supported approximately similar arthropod populations in terms of relative abundance and diversity. These results indicate that the relatively few arthropods which were found on mountain mahogany in September 1974 was due to the leaves of the plants senescing rather than to any natural resistance to arthropods.

4. Parasite-Host Relationships

The major ectoparasites of small mammal species on the Tract are lice, mites, ticks and fleas. The latter two groups are of greater interest because they are the most numerous on small mammals on the Tract, and because of their disease transmission potential. Ticks have been implicated in the transmission of a number of diseases in the Western states. Dermacentor andersoni, a hard-bodied tick is a known carrier of Rocky Mountain Spotted Fever and Colorado Tick Fever, and is abundant on the Tract. A number of fleas are also known vectors of plague in the west. One of these species, Diamanus montanus, has been identified from squirrels around the Tract.

These ectoparasites supply their nutritional requirements by taking blood meals from their hosts. Adult ticks become active in the early spring and begin searching for hosts. While on a host, adult ticks breed and then drop to the ground. Females lay their eggs in litter, and when the larvae emerge, they actively seek hosts. The adult Rocky Mountain spotted fever tick, Dermacentor andersoni, is usually found on larger mammals such as porcupine, deer and hares, while the immature stages find intermediate hosts such as deer mice, ground squirrels and woodrats.

All three life history stages (adult, nymph and larva) are found from about April through October on the Tract. The adults have their population peak in the early spring, followed by the larval stage. The larvae can be quite numerous at times and may have two peaks in activity and numbers. Nymphs usually peak in numbers by late summer. All stages require a blood meal to metamorphose to the next stage (larva to nymph, or nymph to adult) or to successfully reproduce (adult females). When winter approaches these ticks hibernate and begin their activity the following spring.

Fleas are common on most small mammals on the Tract and are known vectors of plague. Plague is an infectious disease caused by Pasturella pestis, a bacterium, and is considered a rodent disease known as sylvatic plague. However, it may cause epidemics among humans under certain conditions.

Fleas lay their eggs in the nests of hosts where the larvae hatch, feed on organic material, pupate, and then hatch into the adult. Adults spend their time on the host, but will also leave the host for short periods while the host is on the nest. Although lice and mites are also known vectors of diseases, their importance to any potential disease transmission in and around the Tract is probably not significant. Mites have been implicated with the transmission of encephalitis virus and lice with some typhus fevers.

5. Deer-cattle Competition

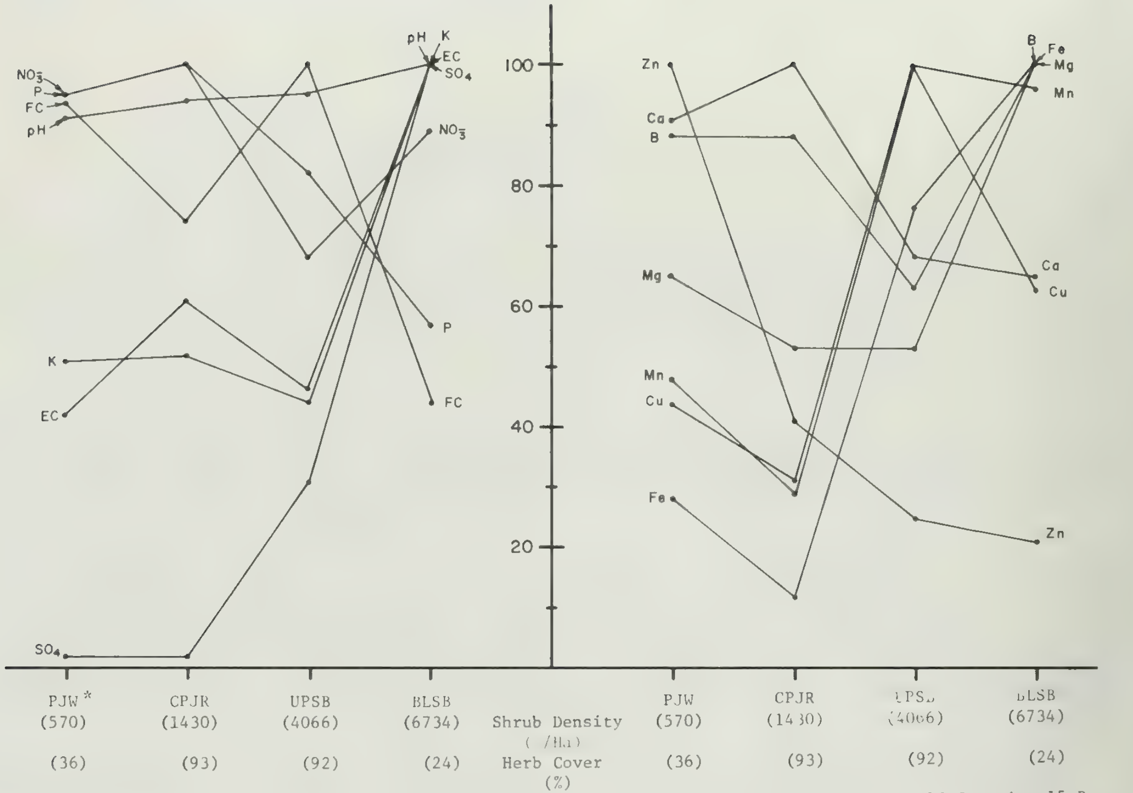
Deer occupy the Tract and surrounding area from approximately mid-October through mid-May. Cattle, on the other hand, utilize the allotment area including the Tract from April to October. Indirect competition may exist if cattle utilize forage which subsequently becomes limiting to the deer population. During severe winter periods any significant decrease in range carrying capacity caused by cattle grazing could result in increased winter mortalities of deer due to malnutrition and attendant problems.

The pattern of cattle use on the Tract was observed from August 1974 through September 1975, and is summarized here. In early spring cattle are released from winter pastures to graze in the agricultural meadows nearby in early spring. As the growing season progresses the cattle move away from the agricultural meadows, pass through the Tract, and summer at higher elevations south of the Tract. At any point in time few cattle are grazing on the Tract. There appear to be no significant differences in 1975 standing crop measurements between cattle exclosures and plots open to grazing at the vegetation study sites. This suggests that no significant grazing takes place on the Tract during the growing season.

As winter approaches, the cattle move down from summer range, pass through the Tract, and utilize the agricultural meadows extensively. Again, during this time a small number of cattle graze on the Tract as they pass through. After November 1974 and October 1975, few cattle, if any, were utilizing the Tract. From one year's observations it appears that deer utilize the Tract heavily from October to May; cattle utilize the Tract very lightly in the spring and fall; and they are virtually absent in June, July and August.

6. Plant-soil Nutrients

Figure XI-41 is a summary of soil characteristics for the major vegetation types on the Tract. This figure shows the relative values for: nitrate, phosphorus, calcium, pH, magnesium, potassium, electrical conductivity, zinc, field capacity, boron, copper, iron and manganese for each of the four major vegetation types. Average shrub densities and herbaceous cover for each vegetation type are also listed for reference.



* PJW-Pinyon-Juniper Woodlands
CPJR-Chained Pinyon-Juniper Rangelands
UPSB-Upland Sagebrush
BLSB-Bottomland Sagebrush

N-Nitrate
P-Phosphorus
K-Potassium
Ca-Calcium
Mg-Magnesium

Mn-Manganese
Zn-Zinc
Cu-Copper
B-Boron
Fe-Iron

FC-Field Capacity 15 Bar
EC-Electrical Conductivity
SO_4-Sulfate

Figure XI-41 SUMMARY OF SOIL CHARACTERISTICS FOR THE FOUR MAJOR VEGETATION TYPES ON TRACT C-b

The preliminary analysis of these data has not shown the presence of strong trends between vegetation and soil. None of the vegetation types have high nutrient regimes, all are deficient in zinc; most are low in phosphorus and potassium. The most revealing features of the nutrient regimes are the differences in woodland and range sites as a group and big sagebrush sites as another group. Both the electrical conductivity (total salts) and sulfate are high in the latter group, as is pH. These low values are accompanied by relatively high levels of nitrate, potassium, copper, manganese, magnesium and iron. Since big sagebrush occurs at high densities on sites with these characteristics there is an implied relationship between the tolerance of sagebrush for high salts, low available water and high pH. There may be some inter-relationship with trace metal values, but this is not descernible at this time. Based on soil productivity assessments (Section XII) the chained rangelands have the most productive soils of the four vegetation types; this being attributed to more substantial populations of soil microorganisms in this vegetation type. Comparisons indicate that pH is an important factor both in the availability of phosphorus, as well as in its influence on the activity of microorganisms, both of which are promoted by lower pH (ca. 7.)

The availability of soil nutrients to plants is influenced by micro-organisms in the soil, by temperature, by soil moisture and by pH. Soil pH, on the other hand, may be influenced by vegetation litter which is mixed with soil. Salt concentrations are another example of plant influence, since certain species of plants absorb substantial quantities of salt and return it to the soil through leaf fall.

7. Wildlife-environment Relationships

Small mammal populations respond to their total environment which includes both biotic and abiotic elements. The biotic elements include intra-species and inter-species interactions ranging from predator-prey relationships to reproductive behavior. Abiotic elements include soils, temperature, precipitation and wind. Surface and subsurface temperatures plus precipitation appear to be important in the initiation and cessation of various rodent activity patterns.

Studies of small mammal population dynamics under natural conditions as they are influenced by abiotic factors are very few. Some generalizations can be made which probably apply to the Tract. First, average soil temperatures influence emergence patterns of hibernating/torpid small mammals (O'Farrell, et al. 1975, Ecol. Monogr. Vol. 45:1-28). Secondly, photoperiod may influence emergence patterns (Kenagy, 1973, Ecol. 54:1201-1219). Thirdly, plant productivity appears to be an important factor in initiating and maintaining reproductive activity in some small rodents (Beatley, 1969, Ecol. 50:721-724; O'Farrell, et al., as above). Fourthly, high summer temperatures force some small rodents underground to avoid thermal problems (French, et al., 1967, J. Mamm. 48:537-548; O'Farrell, et al., as above). And finally, a relationship exists between peak summer rodent populations and the previous years' winter precipitation (O'Farrell, et al., as above).

Subjective evaluation of small rodent activity on the Tract suggests that the above factors are probably important. For example, during inclement weather (low morning temperatures and precipitation) in the early spring, above-ground activity was sharply curtailed. This same phenomemon was observed in the fall.

Meterological data available for the trapping grids is yet to be analyzed and correlated with small mammal population characteristics to determine relationships.

8. Vegetation-environment Relationships

The generalized schematic:

$$\begin{tikzcd} & \text{Climate} \arrow[dl] \arrow[dr] & \\ \text{Vegetation} \arrow[rr, leftrightarrow] & & \text{Soils} \end{tikzcd}$$

is a simplistic expression of the relationship between vegetation and the environment. As the schematic implies, both vegetation and soil are causally determined by climate and (secondarily) by their own interrelationships.

The principal influences of climate (and microclimate) on vegetation and soils are temperature and precipitation. Although other factors are also determining,(such as topography, time, geologic materials, and other organisms) climate is a predominant influence on these as well.

Temperature regimes in soils determine weathering rates and the types of vegetation which the soil can support. Precipitation, as it affects soil moisture regimes, is an equal determinant on vegetation development. The effects of temperature in free air also interact with vegetation by influencing developmental events such as germination and flowering.

The principal interactions between soils and vegetation are morphological and chemical . Important soil morphological features include permeability, moisture, capacity and texture. These properties determine, to an extent, root penetration and moisture stress for plants. The entire nutrient regime of major, minor and trace elements constitutes the soil chemistry-vegetation interface. These elements have been listed and discussed in Section XII. Plant amendments such as dead fall, leaf and bark litter integrate with soil chemical properties. Structural features of vegetation such as canopy cover and root form have influences on the weathering characteristics of soils.

Figures XI-42 through XI-44 are summaries of environmental data relative to vegetation. These figures have been constructed from data gathered in the four major vegetation types on the Tract: pinyon-juniper woodlands, chained pinyon-juniper rangelands, upland sagebrush sites and bottomland sagebrush sites.

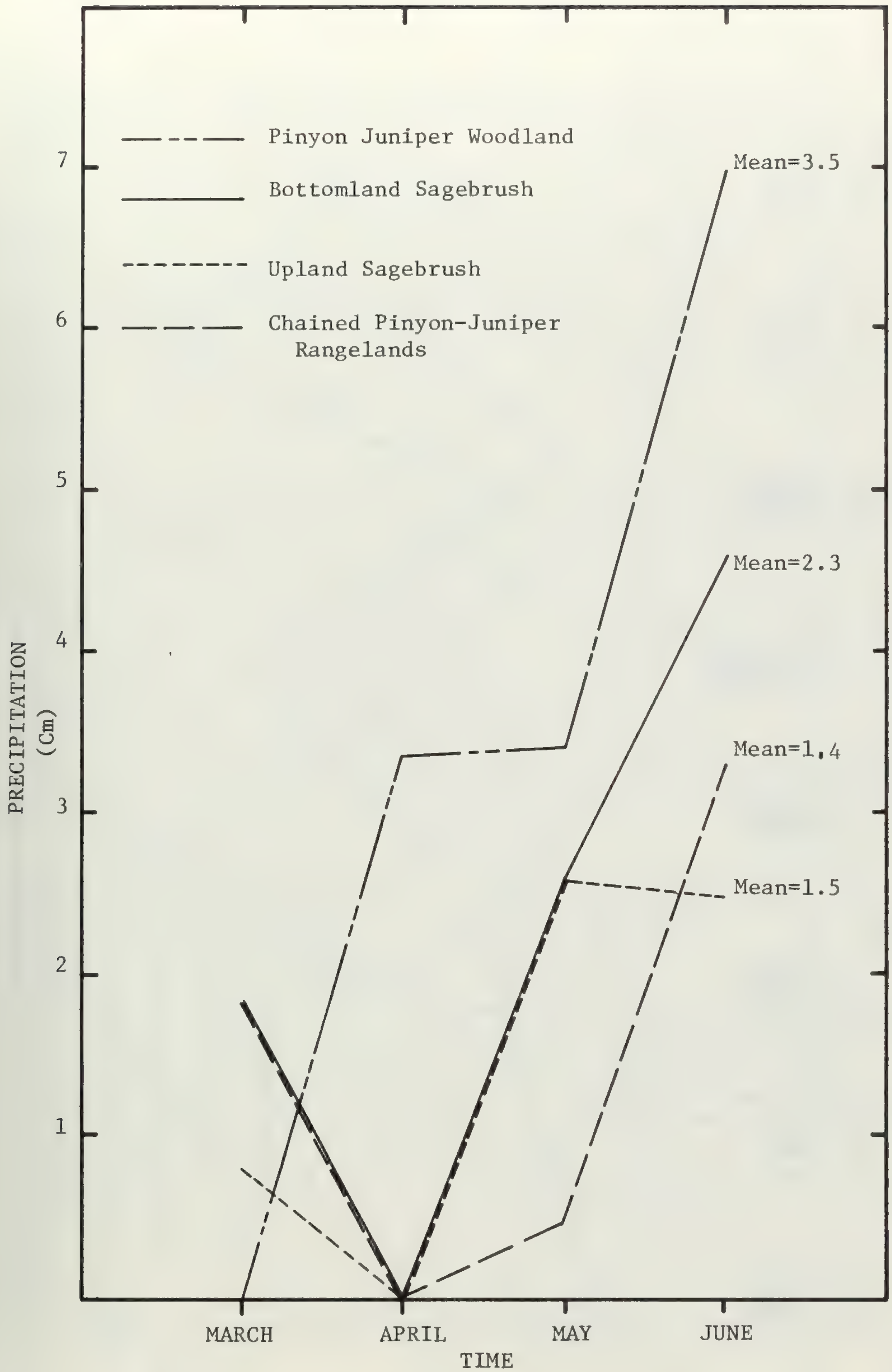


Figure XI-42 PRECIPITATION SUMMARY FOR THE FOUR MAJOR VEGETATION TYPES IN THE TRACT C-b STUDY AREA

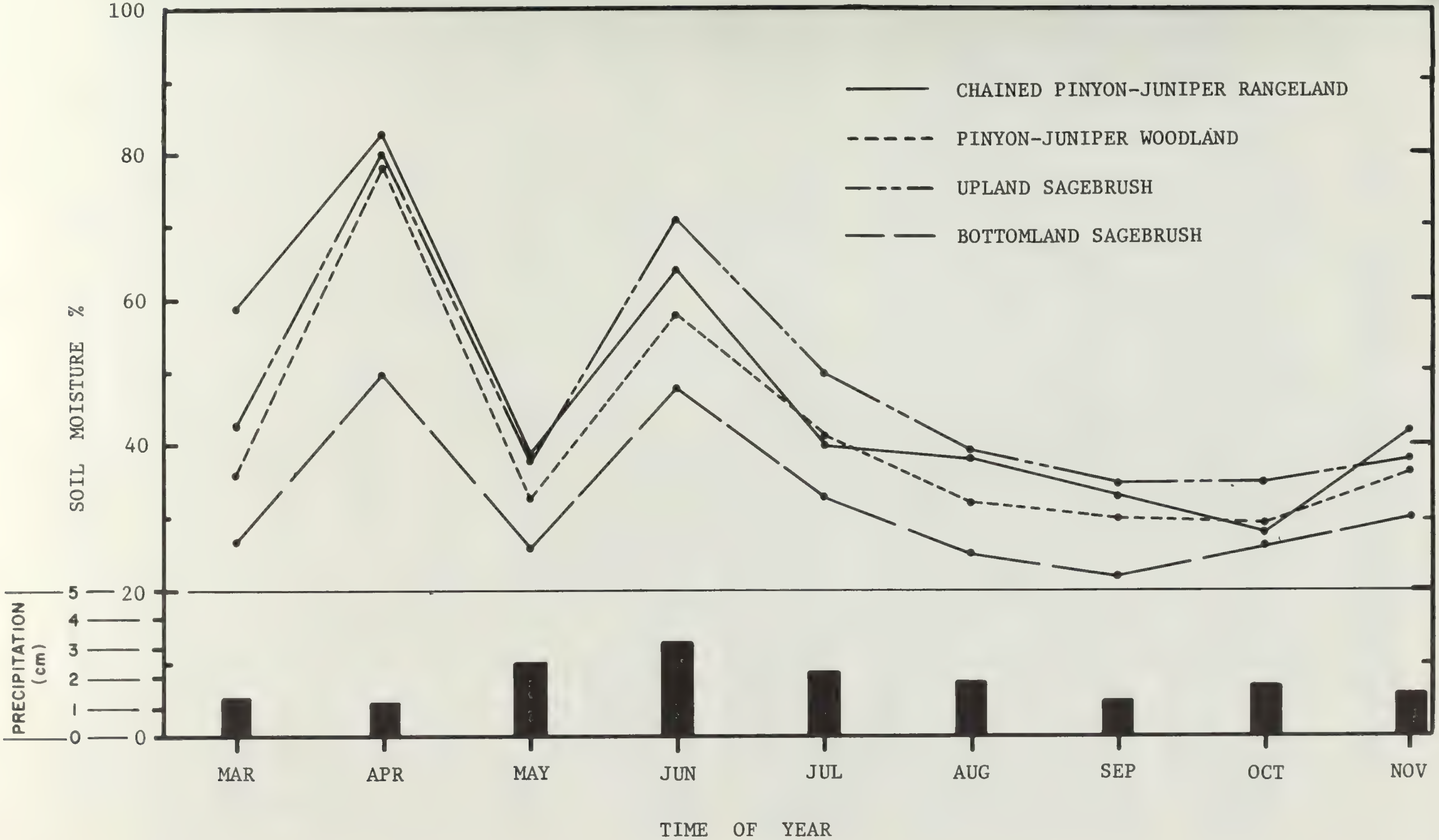


Figure XI-43 SOIL MOISTURE SUMMARY FOR THE FOUR MAJOR VEGETATION TYPES IN THE TRACT C-b STUDY AREA

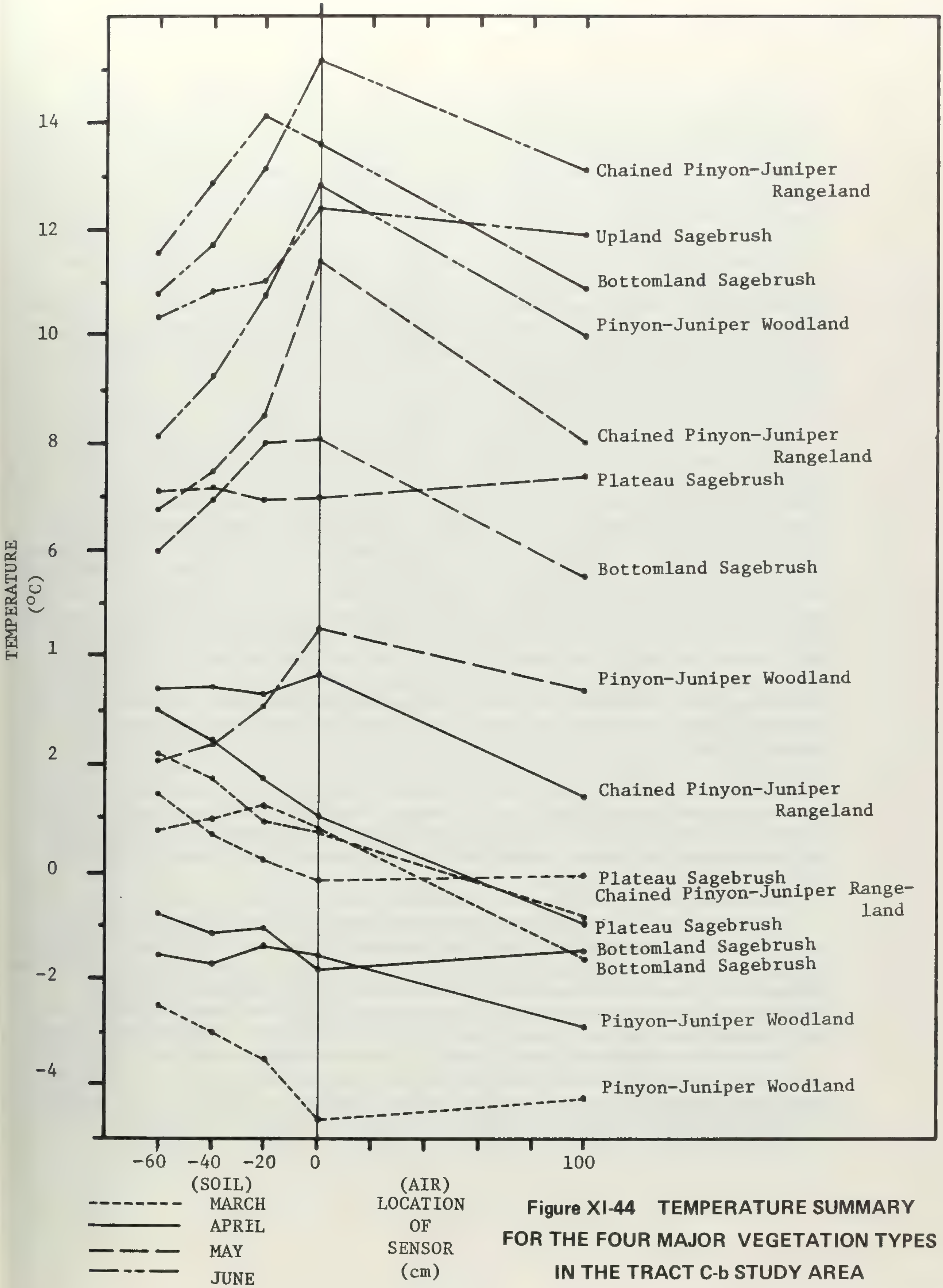


Figure XI-44 TEMPERATURE SUMMARY FOR THE FOUR MAJOR VEGETATION TYPES IN THE TRACT C-b STUDY AREA

a. Precipitation

The precipitation record for the Tract does not reveal any evidence of precipitation trends in terms of vegetation type distribution. A part of this record (for the period from March, 1975 through June, 1975) is shown in Figure XI-42. This figure demonstrates the sporadic nature of rainfall over the Tract area. Although pinyon-juniper woodlands are shown as receiving the greatest amount of precipitation for the period at a mean value of 3.5 cm, other records from spot-check stations show pinyon-juniper sites receiving less moisture. The importance of precipitation in supporting vegetation is apparently a more regional factor. The influence of moisture in supporting different types of vegetation is more a function of soil morphology in terms of water availability than is precipitation as an independent variable.

b. Soil Moisture and Field Capacity

Soil moisture data collected for the four major vegetation types from March through October, 1975 are shown in Figure XI-43. These data somewhat reflect the nature of cyclic changes in the soil moisture regime of the vegetation types on the Tract. There is an overall tendency for soil moisture to be high in the early spring as a result of the infiltration of snow melt. Big sagebrush stands tend to dry out more rapidly than the rangelands and woodlands; and tend to remain drier through the summer months. This may be attributable to the fine-grained nature of the soils underlying these types. The woodland sites remain more moist than the other sites through the summer, but do not respond as markedly to fall precipitation as do the other three vegetation types. This seems to reinforce the importance of winter moisture to the growth of tree species as reported in the dendroclimatological section included in the third Quarterly Report.

The low values in May for all sites are possibly the result of soil water loss due to infiltration of moisture through the lower soil strata which were previously frozen, and increased water use by plants during the resumption of early season growth. Increases into June are the result of early summer rains.

The soil moisture data summaries compare favorably with field capacity values (Figure XI-43). Pinyon-juniper woodlands and upland sagebrush sites have the highest field capacity values. The low soil moisture values in upland sagebrush sites are due to high insolation and the desiccating effects of wind. The field capacity data together with the soil moisture data, indicate that (1) these soils are capable of holding sufficient quantities of water, and (2) that this water is available for revegetation at the period when growth of vegetation is resuming. The low field capacity values for bottomland sagebrush sites is borne out by low mean soil moisture. Chained pinyon-juniper rangelands appear to be intermediate with respect to both soil moisture and field capacity.

c. Temperature

Figure XI-44 shows temperature profiles for the four major plant community types on the Tract for the months of March, April, May and June. These profiles have been constructed from monthly mean values from continuous temperature records in four sites. The values listed were collected at three soil depths, one surface location and one free air location.

All sites show two similar patterns with respect to differences in soil and air temperature. Soil temperatures show an overall narrow range, changing relatively little in comparison to air temperatures between seasons. The seasonal change involved between spring and early summer shows the inverted relationship of soil temperature to surface and air temperature. This is the expected pattern of response resulting from the fact that soils gain and lose heat more slowly than air, and that a surface does not conduct heat away as rapidly as free air and gains heat more rapidly than soil at depth.

As a general observation, the warmest, most variable sites are the chained rangelands; the coldest sites are the pinyon-juniper woodlands. Bottomland and upland sagebrush sites are intermediate, the latter generally cooler.

Chained Pinyon-juniper Rangelands. This is the warmest of the four major vegetation types. The temperature differences between extremes in depth and height are the greatest in all sites. The behavior of the profile is markedly similar to that of the woodland site. This would indicate the overall similarity of primary controlling factors, such as soil type and high vegetation profile (to the one meter level). The marked differences in actual temperature between these two types must be due to the absence of a canopy in the chained sites, increasing the effective level of solar insolation. The correspondence of behavior in temperature profiles in these two structurally different sites is a good indication that the controlling factors on heat distribution in soils are texture and permeability. In air, these are factors which influence heat gain during daylight hours and heat loss at night, such as vegetation structures which maintain heat strata by stabilizing air distribution and flow; and topographic features which determine the operation of phenomena such as cold air drainage.

Bottomland Sagebrush. The unique temperature feature of this type is the behavior of the subsurface temperatures. Instead of the gradual decrease with depth characteristic of warm weather and the gradual increase with depth characteristic of cold weather the extreme subsurface is colder than shallow areas during both warm and cold weather. The shallow soil areas are either warmer than the surface or about the same temperature. The probable mechanism responsible for this phenomenon

is the poor mixing of air above the surface created by dense vegetation greater than one meter in height, in combination with the effect of surface insolution which penetrates the fine-textured soils. This phenomenon also occurs during winter in woodland sites by the same mechanism. Snow pack in both of these sites contributes to the insulating effects in winter. Penetration of moisture in spring contributes to heating the shallow soils in the bottomland sage sites since water conducts heat better than dry soil.

Lower average temperatures at one meter, in contrast to upland sage sites, are the result of cold air drainage in bottomland sites. Apparently, the vegetation height is responsible for limiting the effects of cold air drainage to the level of the shrub crown.

Upland Sagebrush. Temperature records from these sites show more vertical mixing than do these from the other sites. This is shown by a small temperature difference between the surface and free air at one meter height. This relationship appears to be the result of the low profile of the vegetation which would have little retardant effect on air movement. In contrast, the other sites have, to some degree, a higher vegetation profile which significantly channels and buffers moving air.

The upland sagebrush type has a generally weak temperature profile. Although temperatures are intermediate with respect to other sites, the difference in temperatures at all levels is significantly less than in other sites. The greater response of soils at depth to surface heating is apparently the result of shallow, fine textured soils overlying highly fractured materials in combination with good vertical mixing of the free air.

Pinyon-juniper Woodlands. The data collection site for pinyon-juniper woodland is located on a narrow ridge. The woodlands at this site are of the open understory type. Although conditions at this site may differ from dense understory woodlands and woodlands of an open understory type on east and west-facing slopes, it is quite representative of pinyon-juniper woodlands in the study area.

The data derived from this site shows that pinyon-juniper woodlands are the coldest of the four major vegetation types. This relationship is true of the entire temperature profile. The woodlands, together with upland sagebrush sites, receive less effective solar radiation at the surface. In woodland sites this low level of insolution appears to be the result of canopy cover throughout the year and is augmented by snow pack and winds in winter.

Based on these initial analyses, it is apparent that the greatest environmental influences on vegetation are soil moisture and temperature. Additional analyses of data already collected in combination with new data will help to strengthen the definition of these relationships.

9. Aquatic Food Web

The aquatic ecosystem in the streams of the Piceance Creek basin includes interactions between the various organisms studied during the baseline program and others which aid in recycling materials between the living and nonliving portions of the system. Aquatic communities characteristically undergo seasonal changes in species composition and abundance, as well as changes over a period of years. This is a natural phenomenon. The food web involves the transfer of energy from plants through a series of organisms. The periphyton of the streams are the major primary producers which convert basic materials into organic substances through photosynthesis. The periphyton are associated with submerged surfaces and include bacteria, algae, protozoans and other microscopic animals, and often early stages of organisms that grow to become part of the benthos. The benthos are the plants and animals living on or in the stream bottom. In the streams, the majority of these are primarily aquatic insects and larvae. The herbivores feed on the plant material. The aquatic insects and some fish species (mountain sucker, speckled dace) are the major herbivores in the stream. The carnivores feed on the herbivores. The brook trout is the major carnivore in the streams of the Tract. They feed primarily on insects. The major components of the system are being examined in the baseline studies. Quantitative measurements have been made for fish populations, periphyton productivity, benthic invertebrate biomass and abundance, species diversity and water quality parameters. Material from the various levels is eventually decomposed and converted to nutrients for use by plants and periphyton for photosynthesis. There can be interconnected sequences of conversion as well as simple, isolated interactions. A generalized diagram of an ecosystem food web for the Tract C-b area is shown in Figure XI-45.

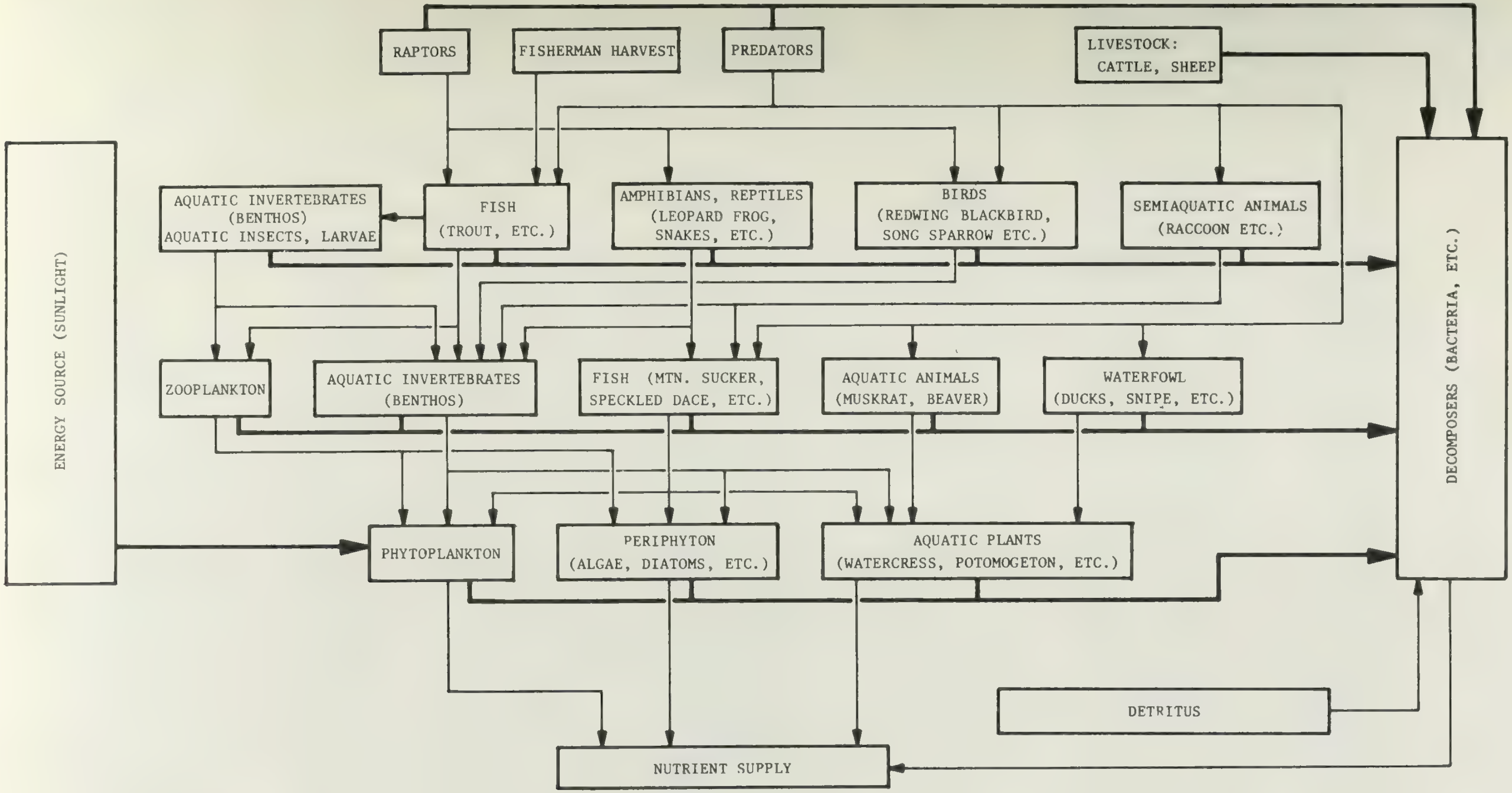


Figure XI-45 GENERALIZED AQUATIC ECOSYSTEM FOOD WEB FOR TRACT C-b

XII. SOIL SURVEY AND PRODUCTIVITY ASSESSMENT

Baseline investigations have provided information on the nature and distribution of soils occurring on the Tract and the one-mile surrounding area. A variety of studies have been completed during the baseline period including: 1) a soil survey, with a classification of soils; 2) a physical description of the representative soil types of each soil series; 3) a map of soil series and representative soil types; 4) an analysis of chemical and physical characteristics of each horizon from each representative soil type; and 4) a correlation of mapped soil units with mapped vegetation units (Figures XII-1 and XII-2). Also included is a productive assessment, including greenhouse experimentation designed to determine the amount of plant material which can be supported by different soil types, and a correlation of experimentation with nutrient analysis.

A. Soil Survey

1. Soil Mapping and Description

The mapping and physical description portion of the soils studies on the Tract has been completed by the U.S. Soil Conservation Service (SCS). The scope of the SCS project includes a study of the entire Piceance Creek basin. The preliminary results of the portion of the study covering the Tract study area may be affected by the completion of the basin-wide survey.

The soil series and types identified by the SCS are presented in Table XII-1. These soil units and their associated vegetation units are mapped in Figure XII-1. The physical and chemical characteristics used in analyzing soils are summarized in Table XII-2. The physical and chemical characteristics of the soils found on the Tract are shown on Table XII-3.

2. Classification of Soils

a. Identification of Soil Taxonomic Units

The soils in this report are classified using the U. S. Department of Agriculture's Soil Classification System (USDS, 1960) adopted for use by the National Cooperative Soil Survey. This is a hierarchical system consisting of six major categories. Each category defines soils as a particular level of abstraction. The highest and broadest category (Soil Order) is useful for studying or comparing soils of very large areas such as countries and continents. The lowest category (Soil Series) defines soils very specifically and is used in detailed surveys.

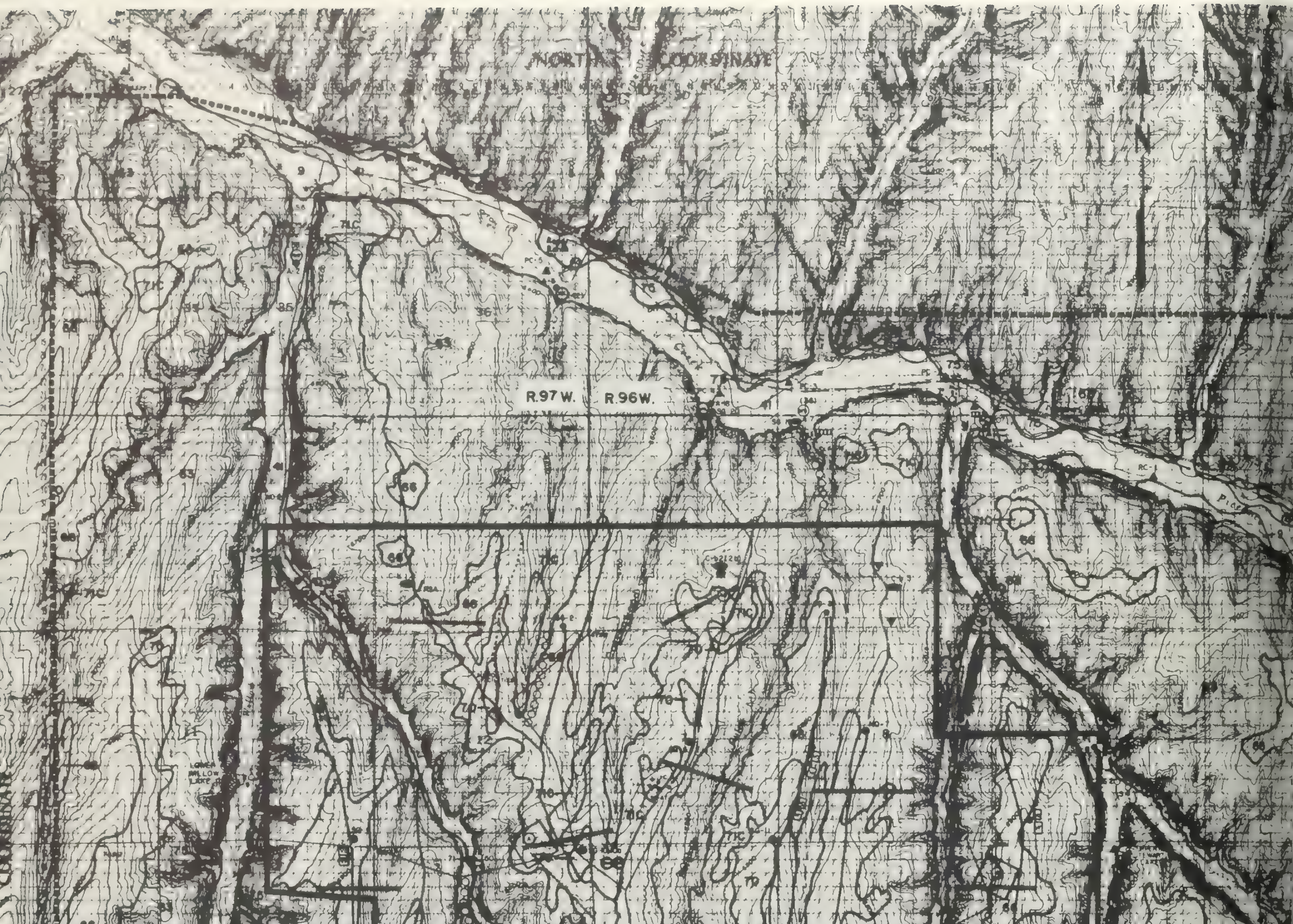


Figure XII—1 SOILS MAP — TRACT C-b

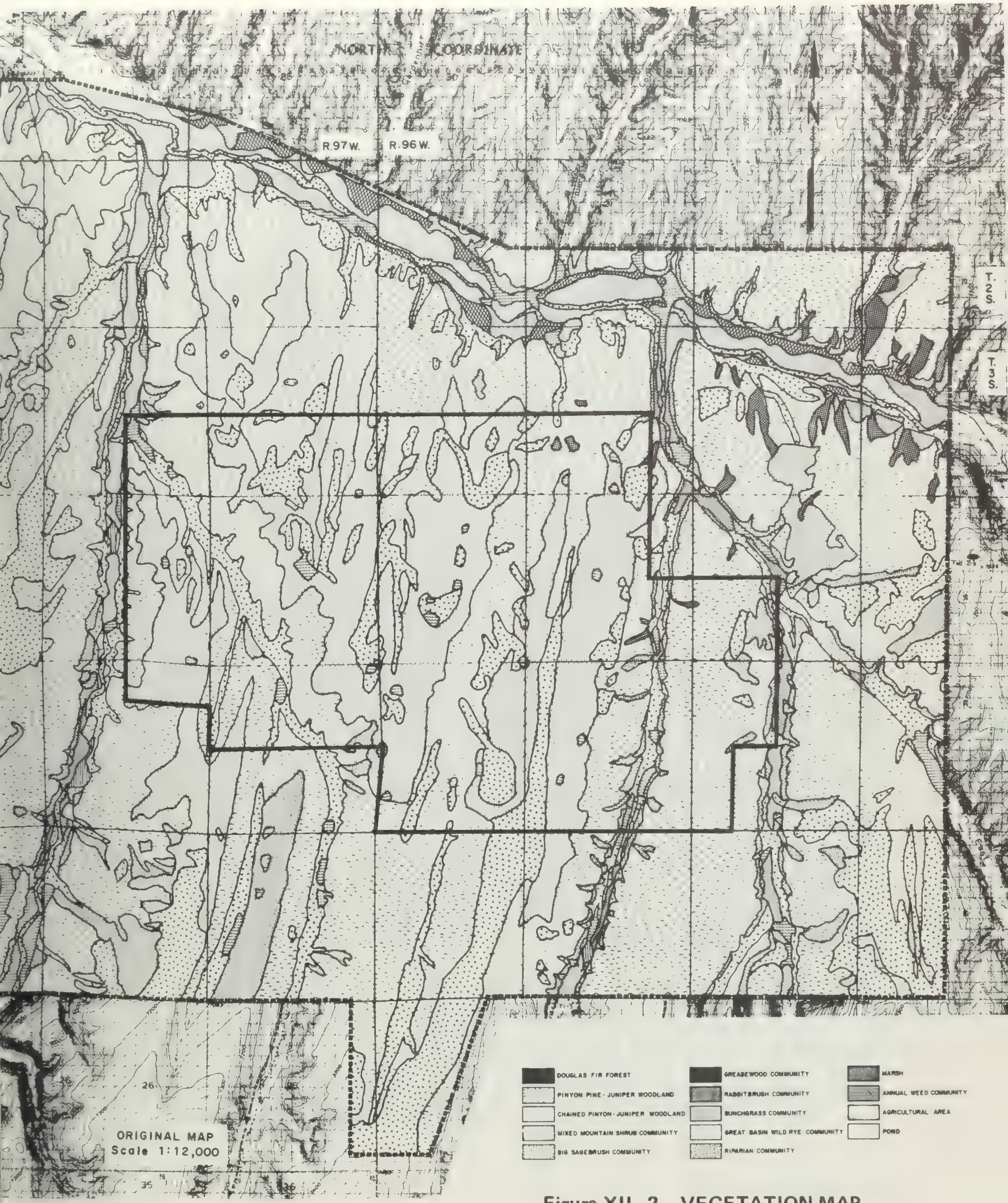


Figure XII–2 VEGETATION MAP TRACT C-b

Table XII–1 SOILS OF TRACT STUDY AREA

(USDA Soil Classification System, 1960)

ORDER	SUBORDER	GREAT GROUP	SUBGROUP	FAMILY	SERIES
ARIDISOLS	Argid	Haplargids	Borallic	Fine Loamy Mixed	Forelle Loam
	Orthids	Camborthids	Borallic	Fine Loamy Mixed	Piceance Fine Sandy Loam
ENTISOLS	Fluvents	Torrifluvents	Ustic	Coarse Loamy Mixed (Cal.) Frigid	Glendive Fine Sandy Loam
			Ustic	Sandy Mixed Frigid	Hanly Loam
			Typic	Fine Loamy Mixed (Cal.) Frigid	Hagga Loam
	Orthents	Torriorthents	Lithic-Ustic	Loamy Mixed (Cal.) Frigid	Redcreek-Rentsac Complex
			Lithic-Ustic	Loamy Skeletal (Cal.) Frigid	Rentsac Channery

Key to Suffixes and Prefixes: Arid = dry; Arg = Clayey; Hapl = minimum horizon; Bor = cool, high organic; Orth = typical; Camb = altered; Ent = recent; Fluv = deposited by water; Torri = dry, low organic; Ust = dry, summer rains; Typ = typical; Lith = rocky

Other Terminology: Cal. = calcareous; Skeletal = interspersed with rock; Channery = containing fine pieces of sandstone or shale

	ORTHENTS					ARGID	ORTHID	ARGID	FLUVENTS		
SOIL TYPE →	REDCREEK-RENTSAC COMPLEX		RENTSAC CHANNERY	REDCREEK-RENTSAC COMPLEX		FORELLE LOAM	PICEANCE LOAM	FORELLE LOAM	GLENDIVE LOAM	HANLEY LOAM	HAGGA LOAM
MAP UNIT	66		63	66		71c	70	71c	41	75	9
SAMPLE NO.	6	9	8	3	10	2	5	4	1	12	11
TEXTURE	SN CL LO (Medium)	SN LO (Light)	SN CL LO (Medium)	SI CL LO (Medium)	SN LO (Light)	SN CL LO (Medium)	CL LO (Medium)	CL LO (Medium)	SN LO (Light)	CL LO (Medium)	SI CL LO (Medium)
% ORGANIC	1.6	0.5	2.7	2.1	3.4	1.9	1.4	1.6	1.9	3.6	1.2
% LIME	1.6	2.4	2.3	8.4	5.2	1.5	3.4	8.8	8.1	5.3	1.8
PH-H20	8.2	8.3	7.9	8.3	8.1	8.2	8.3	8.4	8.7	9.5	8.0
NITRATE-NITROGEN ppm	20.1	12.0	50.3	24.6	39.6	23.6	18.6	16.5	30.0	52.0	35.1
AMMONIA-NITROGEN ppm	1.6	0.3	6.8	2.6	6.7	2.2	1.3	1.3	2.8	2.0	2.1
PHOSPHORUS ppm	1.0	1.0	14.0	10.[illegible]	6.0	5.0	6.0	3.0	16.0	11.0	1.0
POTASSIUM ppm	51.0	53.0	230.0	85.0	93.0	65.0	50.0	49.0	460.0	190.0	55.0
CALCIUM ppm	3400.0	3700.0	3600.0	2600.0	3900.0	4000.0	3800.0	3600.0	1600.0	2000.0	3300.0
MAGNESIUM ppm	300.0	250.0	420.0	1200.0	160.0	350.0	540.0	560.0	920.0	100.0	610.0
SULFATE-SULFUR ppm	15.0	7.0	2.0	270.0	1.0	[illegible].0	10.0	10.0	990.0	4800.0	19.0
IRON ppm	1.4	2.7	3.9	69.0	4.8	.4	1.7	1.3	98.0	27.0	3.0
MANGANESE ppm	5.2	0.9	2.6	15.0	2.4	7.2	6.5	4.8	17.0	13.0	6.8
ZINC ppm	0.1	0.1	0.2	0.2	0.2	0.1	0.1	0.1	0.4	0.3	0.1
BORON ppm	0.3	0.2	1.0	0.2	0.6	0.6	0.4	0.4	0.7	0.6	0.2
COPPER ppm	0.4	0.2	0.4	2.3	0.9	0.6	0.8	0.7	1.5	1.2	0.8
SODIUM ppm	96.6	98.9	94.3	483.0	103.5	103.5	105.8	181.7	1081.0	3080.0	105.8
ESP	0.7	0.8	0.5	5.1	0.5	0.4	0.2	1.8	10.0	42.7	0.2
SALT-EC	1.2	1.3	1.4	2.7	2.1	1.4	1.8	1.3	8.7	7.5	1.5
OMN	64.0	22.5	108.0	84.0	100.0	76.0	56.0	64.0	85.5	120.0	48.0
EXCHANGEABLE: MEQ/100 gm.											
CA	16.6	18.2	17.5	12.0	18.9	19.5	18.5	17.5	7.5	9.8	15.9
MG	2.4	2.0	3.3	9.7	1.2	2.8	4.3	4.5	6.9	0.7	4.9
NA	0.1	0.2	0.1	1.2	0.1	0.1	0.0	0.9	1.7	8.2	0.0
K	0.1	0.1	0.5	0.1	0.2	0.1	0.1	0.1	1.0	0.4	0.1
TOTAL CEC	19.2	20.5	21.5	23.1	20.9	22.5	23.0	22.6	17.1	19.2	21.0
SATURATED SOIL EXTRACT: MEQ/LITER											
CA	6.3	4.9	7.0	12.2	10.8	7.2	6.8	6.2	10.2	2.9	7.1
MG	1.3	2.3	2.4	3.6	3.1	1.6	2.4	2.1	16.2	1.2	2.8
NA	4.1	5.1	4.3	11.9	6.9	5.4	9.7	5.2	61.5	74.5	5.4
K	0.6	1.0	1.0	1.0	1.4	0.5	0.5	0.7	3.7	0.6	0.6
TOTAL	12.3	13.3	14.8	28.7	22.1	14.7	19.5	14.1	91.6	79.1	15.8
SO_4	0.7	0.5	0.2	13.5	0.1	1.7	0.7	0.5	70.7	63.8	1.2
CL	0.4	0.5	0.9	1.3	1.6	0.6	0.7	0.4	4.4	3.8	0.8
CO3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.3	0.0
HCO3	11.0	12.2	13.5	13.5	20.1	12.2	17.8	13.0	16.1	7.8	13.6
TOTAL	12.1	13.1	14.6	28.3	21.8	14.5	19.2	13.9	91.2	78.7	15.6
S.A.R.	2.1	2.7	2.0	4.2	2.6	2.6	4.5	2.6	16.9	52.3	2.4
% GYPSUM	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1
BULK DENSITY	1.59	1.75	1.60	1.48	1.72	1.50	1.54	1.61	1.63	1.41	1.45
PERMEABILITY IN.	0.51	1.62	0.49	0.29	1.57	0.54	0.36	0.35	1.47	0.37	0.30
% FLD CAP 1/3 BAR.	32.2	12.7	27.5	31.2	18.2	31.7	34.8	33.0	18.4	31.1	35.4
% FLD CAP 15 BAR.	17.0	7.5	18.8	23.3	7.2	16.2	20.6	20.6	6.5	18.6	21.0
MOLYBDENUM ppm	0.7	0.5	0.4	1.1	0.4	0.7	0.3	0.3	0.9	0.5	0.4
COBALT ppm	-0.1	-0.1	-0.1	0.2	-0.1	0.1	0.1	-0.1	0.2	-0.1	-0.1
SELENIUM ppm	-0.01	-0.01	-0.01	-0.01	-0.02	-0.01	-0.01	-0.01	0.03	-0.01	-0.01
ARSENIC ppm	0.07	0.06	0.03	0.04	0.08	0.03	0.03	0.07	0.06	0.04	0.06
FLUORIDE ppm	0.18	0.18	0.21	0.51	0.37	0.21	0.30	0.21	0.36	0.31	0.31
NICKEL ppm	1.1	0.8	0.8	2.6	0.9	1.4	1.2	1.3	1.3	1.1	1.5
LEAD ppm	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0
MERCURY ppm	0.004	0.003	0.002	-0.001	0.001	-0.001	0.003	-0.001	-0.001	-0.001	0.005
CADMIUM ppm	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1
ANTIMONY ppm	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0

ANALYSIS

ABBREVIATIONS:

CEC: Cation Exchange Capacity in MG Equiv/100gm.
ESP: Exchangeable Sodium Percentage
SALE-EC: Electrical Conductivity of Saturated Soil Past Extract in MCMHOS/CC
OMN: Estimated Nitrogen Available to Plants in One
SN: Sand or Sandy
SI: Silt or Silty
CL: Clay
LO: Loam or Loamy
S.A.R.: Sodium Adsorption Ratio
-: Indicates Level is Below Reporting Minimum
*: This Table Summarizes the Analyses from the Top Horizon of Each Soil Listed

Table XII-3 SUMMARY OF SOIL ANALYSIS *

Table XII–2 SUMMARY OF SOIL CHEMICAL AND PHYSICAL CHARACTERISTICS

1) Agronomic Bulk Sample (determinations made of available fraction)

a) organic matter
b) potassium
c) phosphates
d) nitrate
e) sulfate
f) calcium
g) iron
h) manganese
i) boron
j) zinc
k) copper
l) magnesium
m) ammonia
n) pH
o) electrical conductivity (soluble salts)
p) exchangeable sodium
q) sodium absorption rate
r) cation exchange capacity
s) gypsum
t) lime

2) Trace elements (determinations made of available fraction)

a) molybdenum
b) cobalt
c) selenium
d) arsenic
e) fluoride
f) nickel
g) lead
h) mercury
i) cadmium
j) antimony

3) Other elements and physical parameters

a) sodium (total)
b) chloride (available)
c) textural analysis
d) bulk density
e) permeability
f) field capacity and wilting point (1/3 Bar & 15 Bar)
g) background alpha and beta radioactivity

Laboratory Methods are described in Quarterly Report #4

b. Interpretations of Soil Taxonomic Units with Respect to Soil Moisture

Names of soils at Order, Suborder and Great Group category levels include an identification of the soil moisture regime. This refers to the presence or absence either of ground water or of water held in the soil (at a tension of 15 bars) in specific horizons for various periods of the year. The solid moisture regime is estimated by considering the moisture condition in the "soil moisture control section." The soil moisture control section is roughly defined as that section which lies between a depth of 4 inches and 12 inches, if the particle-size class is fine-loamy, coarse-silty, fine-silty, or clayey. The moisture control section extends from a depth of 8 to 24 inches if the particle-size class is coarse-loamy, and from 12 to 35 inches if the particle-size class is sandy.

The moisture regime of a soil is important because of its significance in understanding and predicting the amount of soil development, the amount, nature and distribution of organic matter, the base status of soils and the amount of leaching that takes place. The greatest significance, however, is related to the potential for growing different plants.

The soil moisture regimes pertinent to the Tract as presently defined in soil taxonomy are torric and ustic. Torric soils are soils which are dry for the greater part of the growing season and which are never totally wet. Thus these soils are deficient in soil moisture for plant growth. Little or no leaching occurs in this moisture regime, and soluble salts will accumulate in the soil if there is a source for them. Many of the soils in this moisture regime either have physical properties that keep them dry, such as a crusty surface which retards infiltration of water, or they are shallow over bedrock. Soils in the Tract study area with this soil moisture regime include the Haplargids, Camborthids, Torrifluvents and Torriorthents (Table XII-1). Weathering of geologic materials exposed in this environment would be extremely slow.

Ustic soils are those in which overall moisture is limited. Soils having a ustic soil moisture regime have a surplus of moisture (where precipitation exceeds evapotranspiration) in fall and early winter. Leaching can occur during this period. During the spring and early summer, evapotranspiration exceeds precipitation. Sufficient moisture is available for plant growth but very little leaching occurs. Summer is a period of moisture deficiency, limiting growth and/or establishment of plants. Soils in the Tract study area having this soil moisture regime are the Torrifluvents and Torriorthents (Table XII-1).

c. Interpretation of Soil Taxonomic Units With Respect to Soil Temperature

The temperature of a soil is one of its most important properties. Within limits, it controls the possibilities for plant growth and soil formation or development. Temperature also controls biotic activity and the rate at which many other soil-forming processes take place.

The soils of the Tract are included in the frigid and mesic soil temperature regimes. The frigid soil temperature regime has a mean annual temperature lower than 8°C (47°F). Soils of the study area that have this soil temperature are Torrifluvents, Torriorthents and the Camborthids. The mesic soil temperature regime is characterized by soils with a mean annual soil temperature of at least 8°C (47°F) but lower than 15°C (59°F). Soils of the study area having this temperature regime are the Hapalrgids, Camborthids and Torriorthents. Soil-forming materials subjected to this environment would weather at a moderate rate.

d. General Description of Soil Taxonomic Units

The following general description of soils found in the study area is given for the soils at the Suborder level.

(1) Argids

The argid soils are characterized as having thin, light-colored surface horizons low in organic matter, but high in base status. These soils are dry for long periods of time. Because of the low organic matter and generally fine texture, some soils in this group take up water slowly and most rainfall runs off. Water and wind erosion are hazards to these soils. Except for a low nitrogen-supplying ability, these soils generally have a moderate to high fertility status. Most of the soils in this category are characterized as being fine-textured, i.e., having a high clay content. These soils offer particular problems with respect to plant growth. If soluble salts and/or gypsum are leached out, subsidence problems may develop. They may also contain high shrink-swell clays. One argid soil occurs in the study area; a Forelle fine sandy loam (map unit 71C-Figure XII-1, Table XII-1).

(2) Fluvents

Fluvents are subject to flooding, but are not perpetually wet. The soil materials are alluvial sediments and may contain appreciable amounts of organic matter. Fluvents are derived from eroding soils or stream banks. These soils are highly stratified and their chemical and physical properties are highly variable with depth. Soils in this category could be a valuable source of plant growth medium for covering processed oil shale or coarse geologic materials. Fluvents are an important soil suborder in the Tract study area. Included are Glendive Loam (41), which occurs in tributary valley bottoms; Hanly Loam (75); and Hagga Loam (9).

(3) Orthents

Soils in the orthent category represent upland areas where little or no soil development is present. They also represent areas of recent erosional surfaces. These soils have a very low organic matter content and a low fertility status. Landscapes on which these soils occur are characterized as being relatively unstable with respect to water erosion and sediment yield. Orthents are the most common on the Tract. Two orthents are the Redcreek-Rentsac Complex and Rentsac Loam. These soils underlie pinyon pine-juniper woodlands and chained areas.

(4) Orthids

The orthids are similar to the argids except they do not have a strongly developed subsoil. They are either chronologically younger than the argids, or because of slope, parent material or climatic conditions, or a combination of these, soil development has been retarded. If the latter is the case, this suggests that the soils occur on active erosional surfaces and that the degree of severity of droughtiness and erosion hazards would be great. These soils may have a horizon of soluble salt accumulation. And they have thin, light-colored surface horizons low in organic matter. The Piceance (70) series is an orthid occurring in the study area.

e. Classification of Soils on the Tract

Classification of the soils on the Tract is outlined in Table XII-1 and Figure XII-1. Descriptions of the types and classifications follow. All of the soils exhibit common characteristics. They are all in areas that have an average annual precipitation of 14-18 inches; the average annual air temperature ranges from 42-45°F. The frost-free period varies from 80 to 105 days, which means the growing season is short. Most of the soils are best suited for livestock grazing and wildlife habitat. Table XII-4 shows the vegetation associations of the soils found on the Tract.

(1) Aridisols - Argid - Haplargids
#71C Forelle Loam
3 to 8% slopes

This is a deep, well-drained soil on uplands and terrace slopes at elevations of 6000 to 7200 feet. It is formed in fine-textured aeolian deposits. Typically, the surface layer is a brown loam about four inches thick. The sub-soil is a brown, light clay loam about 12 inches thick. The sub-stratum is a very pale brown loam extending to more than 60 inches. There is a layer of strong lime accumulation in the lower sub-soil and sub-stratum. Permeability is moderate. Effective rooting depth is 60 inches or more. Available water capacity is medium. Surface runoff is slow and erosion hazard slight. This soil is used for dryland farming, livestock grazing and wildlife habitat. It is a good source for fine soil material.

Table XII–4 SOILS AND VEGETATION ASSOCIATIONS OF THE TRACT C-b STUDY AREA

VEGETATION TYPE	SOILS						
	HAGGA LOAM	GLENDIVE LOAM	HANLY LOAM	PICEANCE LOAM	FORELLE LOAM	RENTSAC CHANNERY	REDCREEK RENTSAC-COMPLEX
PINYON-JUNIPER WOODLAND				X	X	X	X
CHAINED PINYON-JUNIPER RANGELAND				X	X	X	X
BOTTOMLAND SAGEBRUSH		X	X				
UPLAND SAGEBRUSH				X	X	X	X
MIXED MOUNTAIN SHRUBLAND						X	X
DOUGLAS-FIR FOREST						X	
BUNCHGRASS COMMUNITY					X	X	X
GREASEWOOD COMMUNITY			X				
RABBITBRUSH COMMUNITY		X					
GREAT BASIN WILDRYE COMMUNITY		X					
AGRICULTURAL MEADOWS	X	X	X				
RIPARIAN COMMUNITY	X	X					

Forelle Loam is strongly associated with upland sagebrush communities and may offer a partial explanation for the occurrence of this vegetation type within some pinyon-juniper woodlands and chained rangelands. This soil differs from the soil commonly underlying the pinyon-juniper type (Redcreek and Rentsac series, see below) in being composed of fine, wind-deposited materials, having a generally higher nutrient status, and differs in maintaining higher field capacity levels. This soil is somewhat deficient in both potassium and phosphorus (probably as a result of a high pH of 8.4), but is high in available nitrogen. This soil and all others in the study area are deficient in zinc.

Forelle Loam is also found locally underlying pinyon-juniper woodland and chained rangeland, and bunchgrass communities on west-facing slopes.

(2) Aridisols - Orthids - Camborthids
#70 Piceance fine sandy loam
5 to 15% slopes

This is a moderately deep, well-drained soil on upland slopes and ridges at elevations of 6500 to 7500 feet. It is formed in residuum from sandstone and modified with aeolian material. The surface layer is brown, fine-sandy loam about 10 inches thick. The subsoil is light yellowish brown loam about 12 inches thick. The substratum is very pale brown, very channery sandy loam about 15 inches thick and overlies hard sandstone. A layer of strong lime accumulation is present in the lower part of the subsoil and substratum. Permeability is moderate. Effective rooting depth is 20 to 40 inches. Available water capacity is moderate. Organic matter content in the surface is medium. Surface runoff is slow to medium and erosion hazard slight to moderate. It is a fair to poor source for topsoil because of the depth to rock.

Piceance Loam, like Forelle Loam, is commonly associated with upland sagebrush. It has minimal correspondence with the occurrence of pinyon-juniper woodlands and chained rangelands. Vegetation associated with this soil is used for livestock grazing and wildlife habitat. This soil is high in nitrates, but is low in potassium and phosphorus because of high pH values (8.3).

(3) Entisol - Fluvents - Torrifluvents

(a) #41 Glendive fine sandy loam
2 to 15% slopes

This is a deep, well-drained soil on valley bottoms at 5900 to 7600 feet. It is formed in mixed alluvial materials, mainly derived from sedimentary rocks. Typically, the surface layer is a pale brown, fine-sandy loam about 12 inches thick. The sub-stratum consists of stratified loams, sandy loams and loamy sands to a depth of more than 60 inches. Permeability is moderate. Effective rooting depth is 60 inches or more.

Available water capacity is moderate. Organic matter content in the surface is medium. Surface runoff is slow and erosion hazard slight.

Glendive Fine Sandy Loam predominantely is found underlying bottomland sagebrush communities and agricultural meadowlands. Table XII-4 indicates other, minimal associations of this soil series. This soil is used for irrigated pasture, livestock grazing and wildlife habitat.

The Glendive series has sodium sulfate, and total salt concentrations which may be deleterious to vegetation. These levels, however, may be counteracted by substantially high nitrate levels. This soil is high in other nutrients as well, including potassium and phosphorus; the effects of high pH (8.7) are apparently counteracted by high sulfate levels.

(b) #75 Hanly channery loamy fine sand
2 to 9% slopes

This is a very deep, somewhat exclusively-drained soil on alluvial fans and cones, and on narrow stream bottoms at elevations between 6000 and 6500 feet. It is formed in coarse alluvium of sandstone or mixed sandstone and shale origin. Typically the surface layer is pale brown, channery loamy fine sand about 6 inches thick. The next layers, to a depth of 37 inches, consist of light, yellowish brown channery sand. The substratum between 37 and 60 inches consists of pale brown and light, yellowish-brown channery sand, very channery sand and channery loamy fine sand. The soil is highly calcareous. Permeability is high. Effective rooting depth is 60 inches or more. Available water holding capacity is low. Organic matter content in the surface is low. Surface runoff is slow and erosion hazard is medium.

Hanly Loam supports vegetation types which occur on alluvial fans and cones and narrow valley bottoms, or in proximity to these areas. Vegetation types associated with this soil include bottomland sagebrush, greasewood stands and agricultural meadows. This soil is used almost entirely for range. Vegetation associated with the Hanly soil has a fair potential for cottontail and deer. They use the grasses, forbs and brush on these soils and obtain their shelter primarily from the brush. This soil is dry and shows high values for nitrogen, potassium and phosphorus, but has excessive concentrations of both sodium and sulfate.

(c) #9 Hagga Loam
0 to 5% slopes

This is a very deep, poorly-drained soil on flood plains at elevations of 6000 to 6700 feet. It is formed in calcareous alluvium from mixed sandstone and shale sources. The surface layer is loam, about 25 inches thick, and except for dark lenses, is light gray. This

is underlain at a depth of 25 inches by light gray clay loam. Rust-colored iron mottles are common thoughout the soil. Permeability is moderate to low. Effective rooting depth is 60 inches or more. Available water holding capacity is high. Organic matter content in the surface layer is medium. Surface runoff is very slow, with some ponding. Erosion hazard is slight.

This soil is used for native and seeded grass hay. Limited acreage is seeded to small grain for hay. Yields of the more desirable grasses and small grains are medium. In the fall, local ducks utilize the grasses on Hagga soils; however, they find most of the seeds in poorly drained areas, which are too wet to mow for hay. In evenings, deer concentrate on Hagga soil for the water which is associated with it.

This soil, like most of those on or near the Tract, has a high pH value, which results in low available phosphorus and potassium; nitrate levels are high.

(4) Entisols - Orthents - Torriorthents

(a) #66 Redcreek-Rentsac complex
5 to 30% slopes

These moderately sloping to steep soils are formed in residuum on foothill slopes and ridges at elevations of 6000 to 7600 feet. The Redcreek soil makes up about 60% of the mapping unit #66 and the Rentsac soil makes up about 30%. The Redcreek soil is a shallow, well-drained soil that is formed in residuum from massive, rapidly weathering sandstone. Typically, the surface layer is a pale brown, sandy loam about 6 inches thick. The substratum is a fine channery, sandy loam about 12 inches thick, and rests on massive sandstone. Permeability is moderate to high. The effective rooting depth is 10 to 20 inches, and the available water capacity is low. Surface runoff is slow, and erosion hazard is slight. The Rentsac soil is a shallow, well-drained soil that is formed in residuum from sandstone which is highly fractured and hard. Typically, the surface layer is a pale brown, very channery, sandy loam about seven inches thick and rests on hard fractured sandstone. Permeability is high. Effective rooting depth is 10 to 20 inches, and available water capacity is low. Surface runoff is slow and erosion hazards slight. The thin layers of soils makes this soil unsuited for use as topsoil.

The Redcreek series is a dry, shallow soil, which is low in fertility. Potassium and phosphorus are low, but nitrates are adequate. This soil is commonly associated with pinyon-juniper woodland and chained rangeland, but also underlies bunchgrass communities, mixed mountain brush communities and upland sagebrush. Bunchgrass and upland sagebrush communities associated with this, and the following series, are frequently on burned sites. These soils are used for limited livestock grazing and wildlife habitat.

(b) #63 Rentsac very channery, fine sandy loam
5 to 50% slopes

This is a shallow, well-drained soil on foothills and ridge tops at elevations of 6000 to 7600 feet. It is formed in residuum on sandstone that is usually horizontally fractured. The Rentsac soil comprises about 70% of the map unit #63. The surface layer is a pale brown, very channery sand loam about 4 inches thick. The underlying layer is a pale brown very channery, sandy loam about 7 inches thick. The substratum is a pale brown very flaggy sandy loam about 7 inches thick and overlies fractured hard sandstone. Permeability is high. Effective rooting depth is less than 20 inches. Organic matter content in the surface layer is medium. Availability water capacity is low. Surface runoff is medium and erosion hazard is slight to moderate. As source material, such as topsoil, Rentsac is poor because of its thin layering, inclusion of small stones, and problems of area reclamation.

The Rentsac channery supports plant communities similar to the Redcreek series, with the addition of Douglas-fir. It is not as strongly associated with upland sagebrush. This soil is used for livestock grazing and recreation. It is shallow and dry and has low fertility.

f. Additional Information on Soils

The Soil Survey for the Tract study area categorizes soils according to soil series and the representative soil type in each series is identified. Each soil type has been described in detail by soil horizon. These detailed descriptions are available in Quarterly Data Reports filed with the AOSS.

B. Soil Chemical and Physical Analysis

The chemical and physical characteristics used to analize soils are shown in Table XII-2 and Table XII-3. The possible significance of high or low levels of various constituents are discussed below to aid the reader in understanding these analyses.

1. Analysis Parameters

Texture. Soil texture is evaluated as light, medium or heavy. Light soils are those in which the association of fine particles is loose, resulting in good aeration, adequate water movement and suitable soil-root interfacing which increases cation-exchange. Light soils, however, are subject to erosion. Heavy soil restricts the movement of air and water and may decrease cation-exchange. Heavy soils tend to be acidic; light soils are more basic.

Organic Matter. Organic matter in soil provides, to some degree, direct nutrition to plants. The amounts of available nutrition in organic matter, however, are not great. Not all organic material is beneficial. Some toxic organic substances may be present and have deleterious effects in soils that are not well-drained (i.e., soils with heavy texture).

Lime. Lime decreases acidity and improves the texture of the soil. At very high levels, however, lime concentrations may interfere with calcium and boron metabolism and decrease the availability of phosphorus to plants.

pH. The availability of certain elements to plants is directly related to pH. At high pH levels, phosphorus availability is reduced. pH has similar effects on boron and other trace elements such as iron, zinc and manganese. Very high pH values decrease magnesium and calcium availability. Bacteria and actinomycetes function best at pH values between 6.0 and 7.0, but are not seriously impeded at excessive pH. Fungi do not respond directly to pH values. Nitrate availability correlates directly with micro-organism activity.

Cation-exchange Capacity. Exchangeable soil constituents - cations (such as hydrogen, calcium, potassium and sodium) are necessary for plant growth. Cation-exchange occurs between the plant root and clay fraction of the soil. Cation-exchange capacity relates fairly directly to soil fertility.

Exchangeable Sodium Percentage. Sodium is considered a secondary or micro-nutrient element. In small amounts it is known to increase yields by replacing the action of potassium. In large concentrations, however, sodium is toxic to plants, causing cell plasmolysis (shrinking of protoplasm due to dehydration).

Electrical Conductivity of Saturated Soil. Electrical conductivity is a measure of the amount of soluble salts in the soil. When excessive, soluble salts may cause plant toxicity.

Estimated Nitrogen Available to Plants One Year After Decomposition of Organic Matter. This is a projected estimate of nitrogen availability (See Nitrogen).

Calcium. Calcium is one of the essential plant nutrients. It is vital for the nitrification process. Calcium is also necessary for bud development. High calcium concentrations, however, may interfere with boron metabolism (See Boron).

Magnesium. Magnesium is another of the essential plant nutrients. Magnesium is necessary to the synthesis of chlorophyll.

Potassium. Potassium is an essential nutrient which increases plant vigor and resistance to disease. Potassium also counteracts the effects of too much nitrogen (See Nitrogen). This element aids in the synthesis of starch and the movement of sugar through the plant.

Sodium. (See Exchangeable Sodium Percentage)

Zinc, Iron, Manganese, Copper and Boron. Small amounts of these elements are essential to plants. Although necessary to the overall nutrient regime, all can become toxic to plant growth at high levels. Iron, at high concentrations, interferes with phosphate availability. Manganese also inhibits phosphorus availability, especially in acidic soils.

Phosphorus. Phosphorus is another of the essential major nutrient elements. Phosphorus is doubly important because it influences the absorption of other nutrients by plants. This element is also important to cell division, to the conversion of starch to sugar and to the flowering process.

Sulfur (Sulfate). Sulfur as sulfate is an essential major nutrient element and protein constituent. It is also important in molecules which are involved in cellular respiration.

Nitrogen (Nitrate). Nitrogen as nitrate is essential to plants in the formation of organic components such as proteins, chlorophyll and coenzymes. Nitrogen governs the utilization by plants of such elements as potassium and phosphorus. In high concentrations nitrogen has detrimental effects on plants, such as decreased resistance to disease, retardation of flowering and poor root development. These effects, however, do not occur equally in all plants.

Ammonium Nitrate. This compound is a source of nitrogen both as NH- and NO-.

Chloride. This element is responsible for the stimulation of photosynthesis.

Molybdenum. This trace element is essential to nitrogen-fixation, but is toxic in large amounts.

Cobalt. Cobalt is a necessary element in the nutrition of blue-green algae and is required by certain legumes for the fixation of nitrogen.

Selenium. This trace element appears to stimulate growth in some species, but is toxic at high levels.

Arsenic. In high concentrations this element inhibits metabolic processes in living tissue.

Fluoride. This element acts as a respiratory inhibiter at high concentrations.

2. Interpretation of Results

Although the interpretations of data on chemical and physical characteristics of soils are incomplete, the basic nutrient status of the surface horizons has been interpreted. The results from this part of the investigation are summarized in the following discussion.

The texture of the soils on the Tract range from light to medium. The four textural categories include: (1) sandy loam, (2) sandy clay loam, (3) clay, and (4) silty clay loam. Percent organic matter is generally moderate, but is high in several samples. Percent lime in the surface is characteristically high, as is pH (i.e., pH is basic). Cation exchange capacity is moderate. Electrical conductivity of soils is low to average, except in sagebrush bottom lands and in greasewood stands, both of which have excessively high values. Nitrogen estimated to be available from organic matter decomposition in one year's time is generally moderate, except in those cases where organic matter is high (see above). Calcium concentrations are generally high. Magnesium values are moderate for the most part. Potassium is generally deficient, as is zinc. Sodium and manganese concentrations are moderate in most soils. Sodium is excessive in sites supporting greasewood and big sagebursh. Copper is generally moderate, though it was deficient in one sample from a pinyon-juniper site. Sulphur (sulfate) is excessive in three samples (from sagebrush and greasewood sites), deficient in two samples (pinyon-juniper and sage sites), and moderate to low in the remaining samples. Nitrate values were high in most sites, and excessive (possibly detrimental) in one site (pinyon-juniper). Ammonia results were identical to those of nitrate. Boron values are moderate in most sites and high in a pinyon-juniper site, though not at a toxic level. Table XII-3 summarizes the physical and chemical characteristics of the several soil types found on the Tract.

The high lime percentages in all soil samples are a possible explanation for low available phosphorus levels, as lime inhibits phosphorus availability. Low phosphorus levels may also be the result of pH values in excess of 7.0. The high nitrate values suggest high soil micro-organism concentration, as do high ammonia levels. High to moderate calcium and magnesium values also favorably influence nitrates. Zinc deficiencies may be a result of high pH values, although other trace elements are not affected to the same degree. Low available potassium values appear to be due to the influence of high lime concentrations on micro-organisms. Lime stimulates micro-organism activity, which results in the decrease of available potassium because of its absorption by the microflora.

C. Soil Productivity Assessment

A soil productivity assessment for the Tract was designed to investigate plant growth characteristics occurring in permanent biological study sites on the Tract.

Soil was obtained from seven sites within the Tract, as shown on Figure XII-3 and Table XII-5. The sites selected were located at the vegetation plots and at the animal trapping grids. A field analysis of the general soil conditions indicated that these sites all had differing soils.

The soil samples from each site were subsampled and the subsamples placed in each of three nursery flats, for a total number of 21 experimental flats. Each flat was subdivided into two parts, and seeds of the two selected bioassay species were planted in the flat. The species selected were oats (Avena, sativa var. victory) and barley (Hordeum vulgare var. Briggs). Avena was planted in one half of each sample flat, and Hordeum in the remaining half. Thus, each flat contained 50 seeds of each species for a total of 150 seeds of each species per soil type.

In addition, control flats were set up with a substrate of vermiculite. The controls were treated with Hoagland's solution to provide a nutrient source.

Germination rates of the two species were measured in each soil type and in the control substrate. Growth parameters were measured on 15 plants of each species in all flats for four weeks following germination. The plants were selected for measurement utilizing a random numbers table. Measurements were made of total stem length, number of nodes, internode length and leaf length. Growth rate analysis was ultimately conducted on the total plant height only.

At the end of the four-week growth period, the plants were harvested. All plants were removed from the soil, the shoot lengths measured, dried and weighed to get an oven-dry weight of biomass accumulated over a four-week period. Subsamples of each soil sample were analyzed. The shoot length and biomass data were treated to graphical and statistical analysis in order to substantiate the significance of the differences in the observed productivity of the various soils.

The selected species, H. vulgare var. Briggs and A. sativa var. victory, show no difference in germination between soil types as shown in Table XII-6. However, both species showed greatest growth and biomass accumulation in soil types 2 and 10 (Redcreek-Rentsac Complex) with less production in the other soil samples, but greater production in the vermiculite control, as indicated in Figures XII-4 and XII-5 and Tables XII-7 and XII-8.

Soil sample 2 is significantly more productive in terms of oats and barley than is 10, and sample 10 is significantly more productive than samples 1 (Rentsac Channery Fine Sandy Loam), 3 (Forelle Loam), 4 (Glendive Fine Sandy Loam), 5 (Rentsac Channery Fine Sandy Loam), and 6 (Hagga Loam). (Figures XII-4 and XII-5; Tables XII-7 and XII-8).

Table XII–5 SOIL PRODUCTIVITY TEST SAMPLES

Productivity Assessment Sample Number	Soil Unit Name	Soil Map Symbol
1	Rentsac Channery Fine Sandy Loam	63
2	Redcreek-Rentsac Complex	66
3	Forelle Loam	71C
4	Glendive Fine Sandy Loam	41
5	Rentsac Channery Fine Sandy Loam	63
6	Rentsac Channery Fine Sandy Loam	63
10	Redcreek-Rentsac Complex	66

Table XII–6 GERMINATION RATE COMPARISON FOR SOIL PRODUCTIVITY TEST SAMPLES*

Germination Rate	Calc. x 2	Critical Value x 2	Decision on Null
Hordeum	2.14	14.07	Accept
Avena	3.25	14.07	Accept

* Chi square goodness of fit to test the null hypothesis that no difference in germination rates exists between soil types for hordeum and avena.

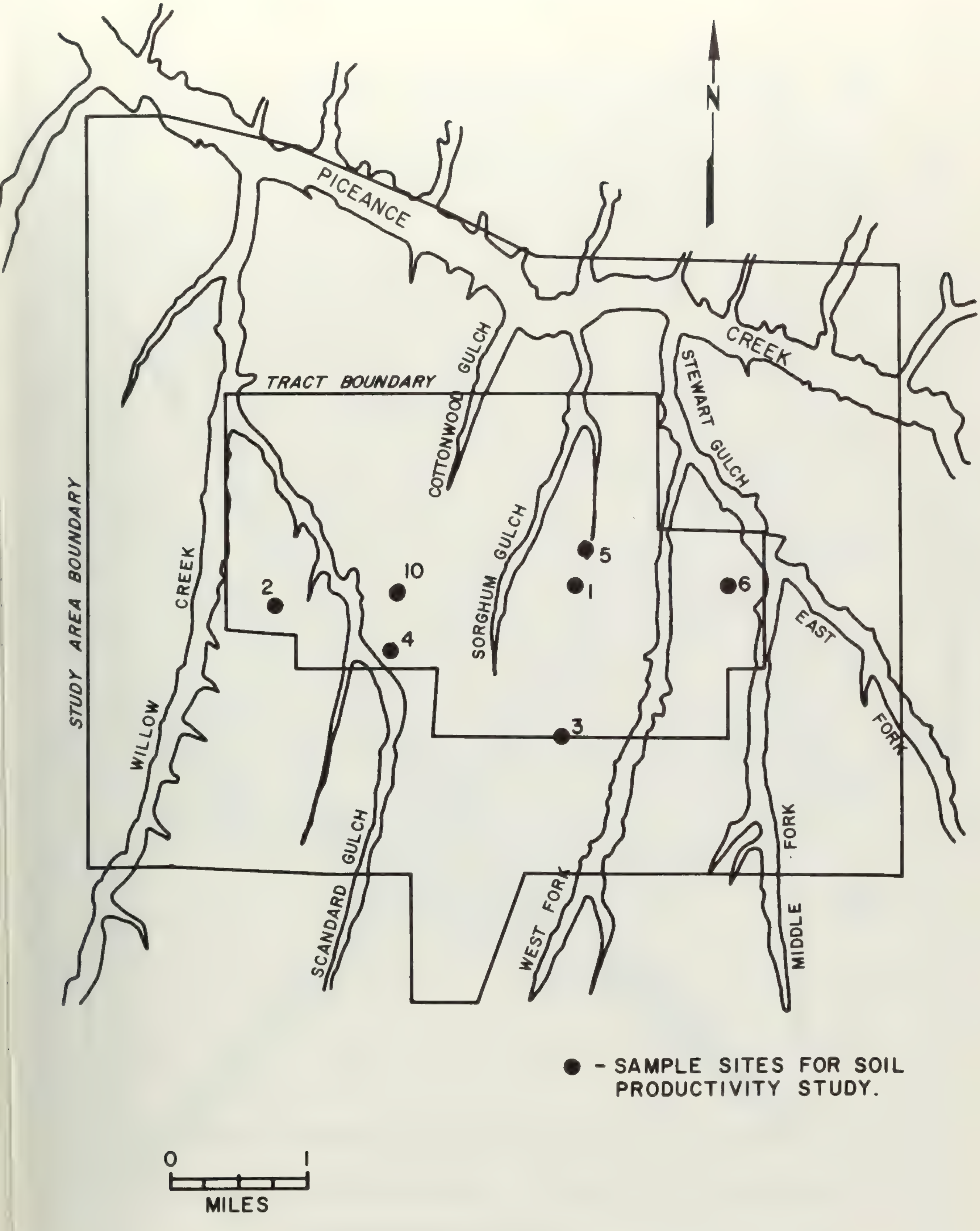


Figure XII—3 SOIL PRODUCTIVITY SAMPLE SITES

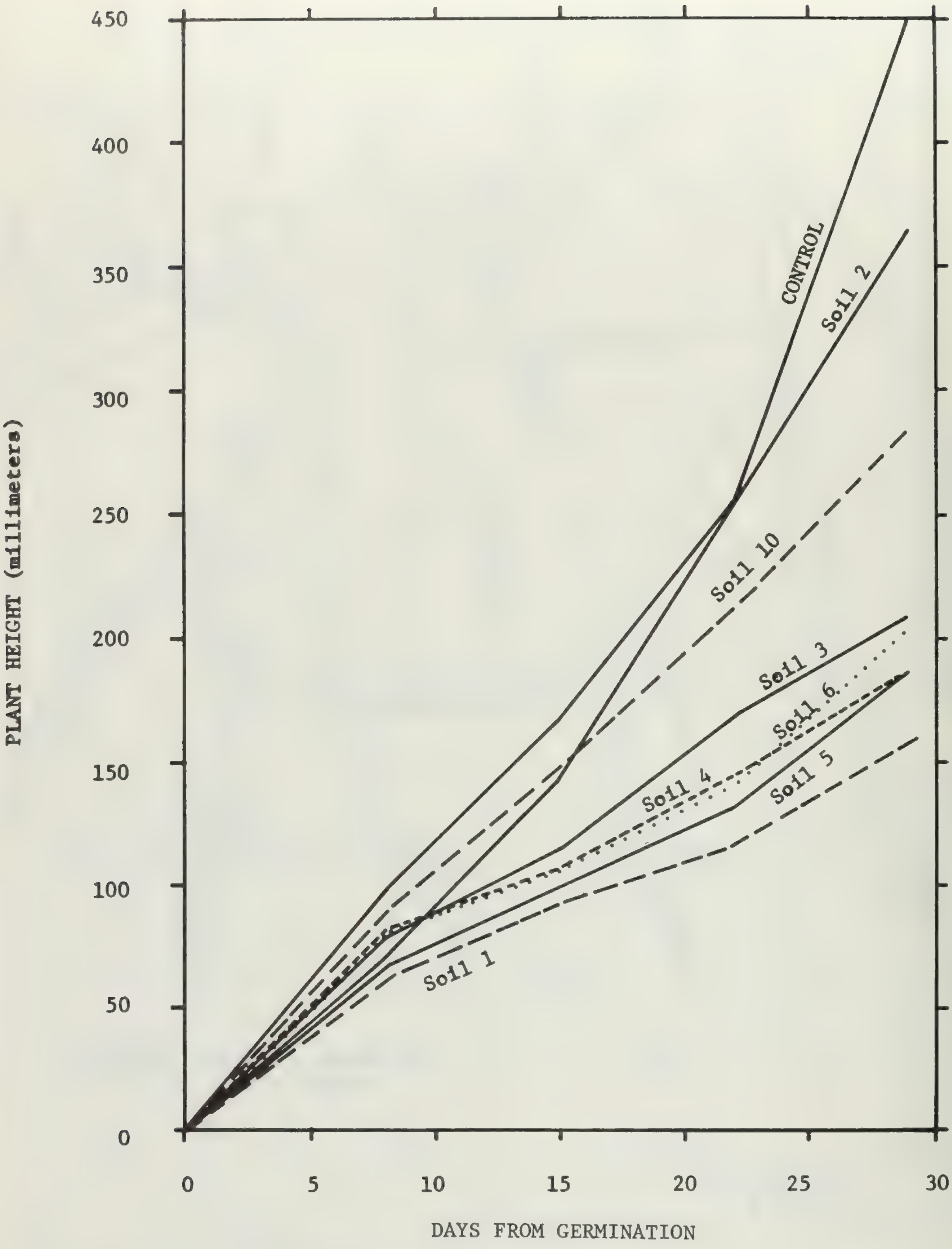


Figure XII—4 SOIL PRODUCTIVITY, GROWTH OF ***AVENA SATIVA*** **VAR.** ***VICTORY***

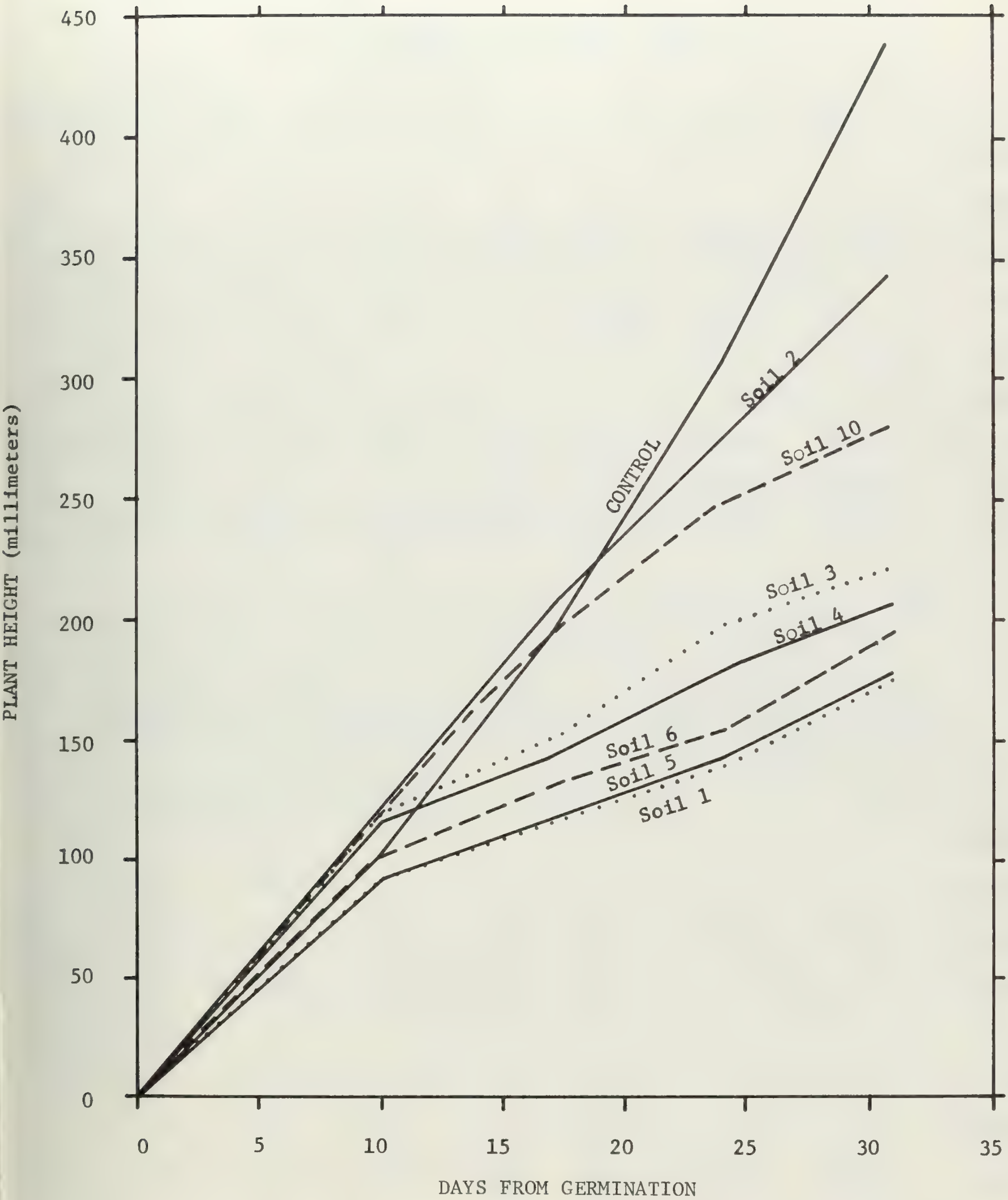


Figure XII–5 SOIL PRODUCTIVITY, GROWTH OF HORDEUM VULGARE VAR. BRIGGS

Table XII–7 SHOOT LENGTH COMPARISON FOR SOIL PRODUCTIVITY TEST SAMPLES

HORDEUM								
Soil Sample	1	5	6	4	3	10	2	C
X Shoot Length	173±13	171±22	193±9	203±18	220±9	277±12	341±29	438±13
Difference	$\tilde{X}_1$ =	$\tilde{X}_5$ =	$\tilde{X}_6$ =	$\tilde{X}_4$ =	$\tilde{X}_3$ =	$\tilde{X}_{10}$ =	$\tilde{X}_2$ =	$\tilde{X}_C$
AVENA								
Soil Sample	1	5	4	6	3	10	2	C
X Shoot Length	152±9	185±21	186±15	201±14	207±15	282±10	363±19	448±24
Difference	$\tilde{X}_1$ =	$\tilde{X}_5$ =	$\tilde{X}_4$ =	$\tilde{X}_6$ =	$\tilde{X}_3$ =	$\tilde{X}_{10}$ =	$\tilde{X}_2$ =	$\tilde{X}_C$

Table XII–8 BIOMASS COMPARISON FOR SOIL PRODUCTIVITY TEST SAMPLES

HORDEUM								
Soil Sample	5	1	6	3	4	10	2	C
X Biomass	.0255	.0267	.0297	.0384	.0387	.0573	.1234	.2184
Difference	$\tilde{X}_5$ ≠	$\tilde{X}_1$ ≠	$\tilde{X}_6$ ≠	$\tilde{X}_3$ ≠	$\tilde{X}_4$ ≠	$\tilde{X}_{10}$ ≠	$\tilde{X}_2$ ≠	$\tilde{X}_C$
AVENA								
Soil Sample	1	5	3	6	4	10	2	C
X Biomass	.0221	.0271	.0317	.0322	.0328	.0542	.1110	.1424
Difference	$\tilde{X}_1$ ≠	$\tilde{X}_5$ ≠	$\tilde{X}_3$ ≠	$\tilde{X}_6$ ≠	$\tilde{X}_4$ ≠	$\tilde{X}_{10}$ ≠	$\tilde{X}_2$ ≠	$\tilde{X}_C$

Samples 1, 3, 4, 5 and 6 are essentially soil samples with low productivity, and samples 2, 10 and the control are different samples having significantly higher productivity in terms of shoot length growth. The biomass data tend to be slightly more complex, with the low productivity soils forming three populations. Samples 3, 6 and 4 are relatively low in productivity compared to 2 and 10, while soil samples 5 and 1 (Rentsac Channery Fine Sandy Loam) are significantly different from each other and lower in productivity than 3, 6 and 4. *Avena* biomass production is lowest in soil sample 1 and *Hordeum* is lowest in sample 5 as indicated in Table XII-9

No significant correlation was found between the nutrient levels occurring in the soils and the productivity of the bioassay species. However, NO_3 levels in soils 2 and 10 are three to five times higher than NO_3 levels in the other soils as indicated in Table XII-10. In addition, phosphorus levels, while low throughout the Tract, are relatively high in samples 2 and 10. Two additional patterns are apparent in the soil analysis data: The SO_4 levels in samples 2 and 10 are two to five times lower than the other sites; and the electrical conductivity test for salts indicates that the salt content of samples 2 and 10 is up to two-times that of the less-productive soils.

No trends were noted in the other soil analysis data. All other parameters analyzed (cation-exchange capacity, soil water retention, etc.) exhibited overlapping variations in magnitude.

The relatively higher salt content and lower sulfur content of soils 2 and 10 are generally considered to be disadvantageous to plant growth. However, these conditions are apparently countered by the higher level of NO_3 and slightly increased level of phosphorus in the more productive soils. The high level of available NO_3 appears to be the most important difference between the Tract soils in the areas around soil sample sites 2 and 10 and those in the other five sites. Since the NH levels are similar at most sites, larger populations of nitrifying bacteria may be present at sample sites 2 and 10, thus making increased NO_3 available for plant growth.

Table XII–9 ANALYSES OF SHOOT LENGTH VS. BIOMASS FOR SOIL PRODUCTIVITY TEST SAMPLES

HORDEUM		Regression Equation	Correlation Coefficient (r)	Regression Critical F	ANOVA Decision	Confidence Limits Of B (slope)
Soil	1	$\hat{y}$ = .0002X-.0148	.9269	41.67	Reject	.0002±.00007
	2	$\hat{y}$ = .0006X-.0932	.7812	68.41	Reject	.0006±.0001
	3	$\hat{y}$ = .0002X-.0221	.7239	60.00	Reject	.0002±.00007
	4	$\hat{y}$ = .0002X-.0112	.7692	66.98	Reject	.0002±.00004
	5	$\hat{y}$ = .0002X-.0154	.9465	550.00	Reject	.0002±.00002
	6	$\hat{y}$ = .0002X-.0218	.8194	115.00	Reject	.0002±.00005
	10	$\hat{y}$ = .0004X-.0596	.8842	148.75	Reject	.0004±.00006
	C	$\hat{y}$ = .0004X-.0406	.3222	5.0232	Reject	.0004±.0003

AVENA						
Soil	1	$\hat{y}$ = .0002X-.01	.7928	87.48	Reject	.0002±.00004
	2	$\hat{y}$ = .0008X-.1969	.8960	176.04	Reject	.0008±.00012
	3	$\hat{y}$ = .0002X-.0161	.8407	112.21	Reject	.0002±.00004
	4	$\hat{y}$ = .0002X-.0086	.8705	143.15	Reject	.0002±.00002
	5	$\hat{y}$ = .0002X-.0132	.9522	622.73	Reject	.0002±.000001
	6	$\hat{y}$ = .0002X-.0083	.7437	66.67	Reject	.0002±.00004
	10	$\hat{y}$ = .003X-.0468	.9054	231.67	Reject	.0003±.00004
	C	$\hat{y}$ = .0005X-.0965	.5532	19.67	Reject	.0005±.0002

Critical Value F (.05) = 4.07

Table XII–10 NUTRIENT ANALYSIS FOR SOIL PRODUCTIVITY TEST SAMPLES

Nutrients (ppm)	Soil Samples 1 (63)	2 (66)	3 (71C)	4 (41)	5 (63)	6 (63)	10 (66)
NO_3-N	5	27	6	10	7	7	38
NH_4-N	28	39	18	23	38	38	46
P	6	26	16	2	7	24	30
K	120	130	250	300	130	220	490
Ca	4900	2900	2600	3400	4200	2600	4100
Mg	200	380	550	230	290	410	340
SO_4-S	17	6	37	10	27	14	5
Fe	5.2	10	7.2	2.6	9.7	29	6.6
Zn	.5	.4	.5	.2	.5	3.6	1.3
Cu	.7	.3	.8	.5	.5	1.3	.7
Mn	1.0	1.9	3.7	.9	1.4	9.6	2.5
B	.5	.8	.8	.9	.5	.6	1.2
Salts $ECx10^3$	.28	.47	.27	.31	.32	.29	.58
Water – Holding Capacity, 15 BAR	11	10	14	10	16	18	17

XIII. SCENIC AND ARCHAEOLOGICAL VALUES

A. Scenic Values

1. General Introduction

A study was undertaken to determine the type and quality of the scenic resources presently existing in the Tract area. The objectives of the study were to characterize the scenic elements of the Piceance Creek basin both as they relate specifically to the Tract and also as they are related to the scenic resources of surrounding areas in Western Colorado. This information was then used to define and evaluate areas of visual sensitivity on the Tract.

The methodology and guidelines used in this study are those used by the U. S. Forest Service in its Visual Management System (USDA Handbook No. 462). A diagrammatic representation of this methodology is shown in Figure XIII-1. The figure illustrates the sequence of steps in this methodology which lead to the determination of visual sensitivity levels of the landscape. A complete discussion of each phase of the study follows. The intensive study area covers the Tract and a zone within 4 miles of the Tract boundary as shown in Figure XIII-2.

2. Landscape Factors

a. Character Type

Visual character type is based on common distinguishing visual characteristics of an area of land. Character type is determined, in this U. S. Forest Service method, by physiographic sections as defined by Fenneman in "Physiography of the Western United States."

The Piceance Creek basin is included in Fenneman's Uinta basin physiographic section. The Uinta basin section is approximately bounded on the north by the Uinta Mountains, on the east by the Park Range and on the south by the Book Cliffs. In general the interior of the Uinta basin section is topographically lower than the margins. The interior of the basin is characterized by a series of high plateaus which are separated by the major drainages of the region.

b. Character Subtypes

In order to more effectively describe the landscape types of the region, it is sometimes necessary to define visually-distinct subtypes of the character type. Visual subtypes described in this study are the: Piceance Creek basin, Book Cliffs, Roan Cliffs, Colorado River valley, Grand Mesa, Grand Hogback, Colorow Mountains, Flattops and Cathedral Bluffs-Douglas Creek. The location of these subtypes are

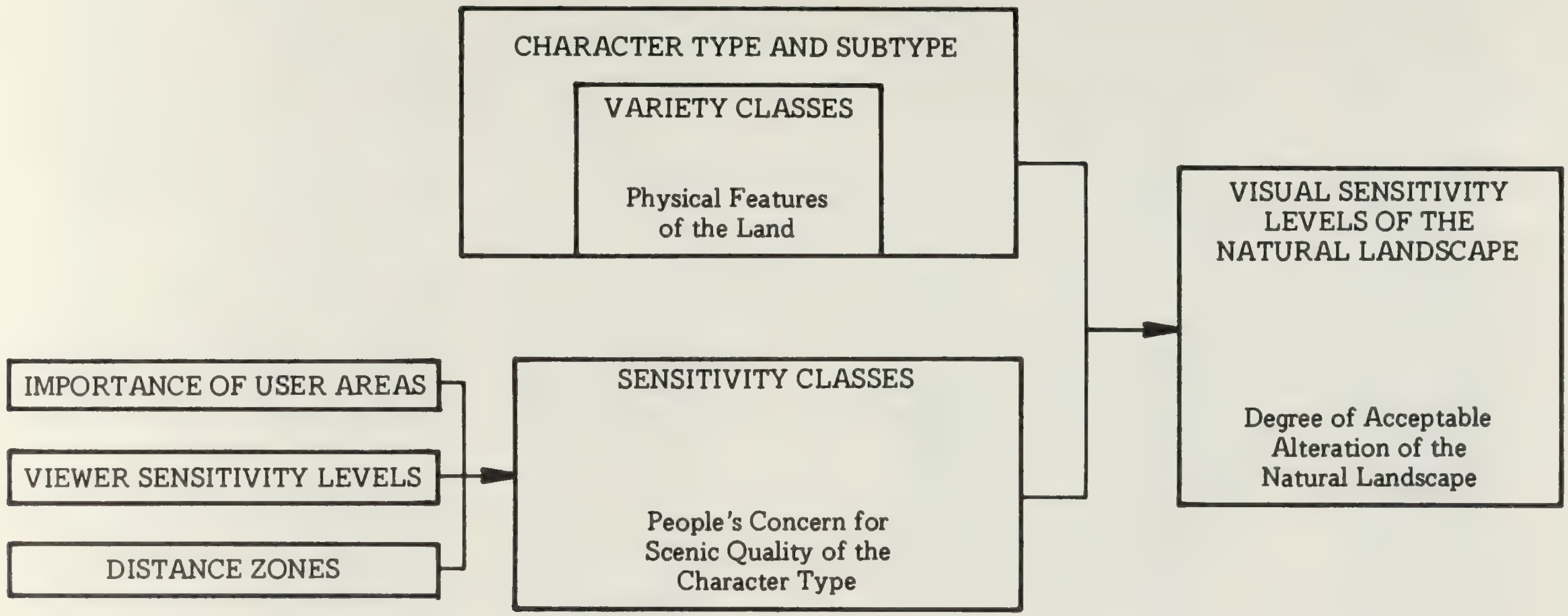


Figure XIII–1 U.S. FOREST SERVICE VISUAL MANAGEMENT SYSTEM

Figure XIII–2 VISUAL QUALITY ANALYSIS
INTENSIVE STUDY AREA

shown in Figure XIII-3 and described below in terms of form, line, color and texture - the basic components of any landscape.

(1) Piceance Creek basin

This subtype is characterized by a gently sloping basin which is moderately dissected by parallel drainages. The stream valleys are bordered by walls which vary from steep cliffs to low rolling slopes. Streambeds are generally narrow and most streams are ephemeral. These drainages lead to the Piceance Creek valley, which is a slightly larger version of its tributaries. Line is smooth and strongly horizontal. Colors are the beige of the eroded sandstone substrate and rock outcroppings, the muted green of sagebrush and darker greens of pinyon-juniper and Douglas-fir vegetation. Valley bottoms range in color from muted sage green to the brighter green of irrigated hay meadows. Texture ranges from the very smooth irrigated meadows to coarser rock outcroppings and fairly coarse, mottled, natural vegetation areas.

(2) Book Cliffs

This subtype is characterized by cliffs approximately 2000 feet high capped with strong horizontal sandstone layers. Steeply eroded, sharp-angled gullies on the cliff faces lead down into gently rolling terrain. The tops of the cliffs form a strong line cutting horizontally across the skyline. The predominant colors of the landscape are the gray of the bottom of the cliffs, which grades into light beige at the top, intermixed with sandy pink and gold-toned horizontal bands. The texture of the cliffs is smooth, as they contain no vegetation. This grades into the fine texture of the sparse vegetation on the lower terrain.

(3) Roan Cliffs

This subtype is characterized by cliffs approximately 3000 feet high with massive block forms at the top. The cliff faces have highly eroded, long steep slopes which are interspersed with areas of relatively small jutting rocks of strong form. The cliff tops cut into the skyline with rounded, massively blocked lines. The color of the landscape is light gray, with several horizontal reddish bands near the bottom of the cliffs. The texture of the steep, eroded slopes is smooth, interspersed with areas of coarse texture resulting from the occurrence of juniper and Douglas-fir vegetation.

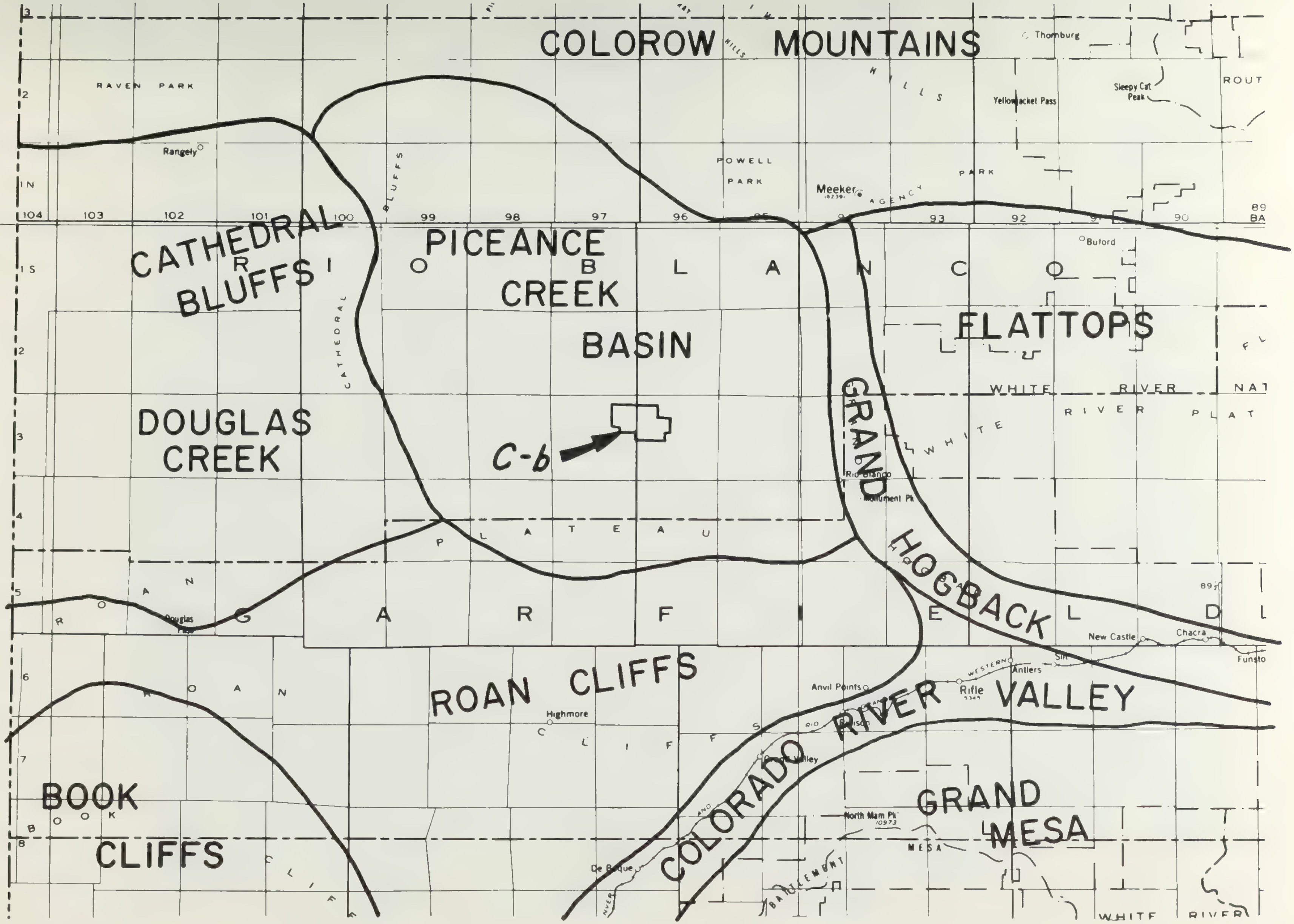


Figure XIII–3 VISUAL CHARACTER SUB TYPES

(4) Colorado River valley

This subtype is characterized by benchlands formed by the cutting of the river. The river is bordered by tall trees. The lines are strong, low and horizontal. Vegetation colors range from sage green to dark green. Soil color is typically tan or beige. The texture is moderately coarse. The cottonwoods produce a rough texture contrasting with the smoothness of the river.

(5) Grand Mesa

This subtype consists of a flat to very gently rolling mesa top situated at 10,000 feet elevation surrounded by slightly angular foothills with gentle sloping sides. The line is strongly horizontal and is strengthened by a 200-foot to 300-foot escarpment immediately below the mesa top. Colors are primarily the green shades of the vegetation, dominated by the dark green of the evergreens. Texture grades from the smooth, large open spaces of the western portion of the mesa top to the coarse texture of the continuous tree cover of the eastern portion. Many lakes are present on the mesa top. The foothills are coarsely-textured, due to the heavy evergreen forest cover.

(6) Grand Hogback

This subtype is characterized by strongly upwarped pointed and plate-like strata rimmed by smaller rocks. The line is predominantly from the diagonals of the tilted strata. The vegetation of the mountains (mountain shrub, pinyon-juniper and Douglas-fir) gives a dark green color and coarse texture interspersed with the banded (reddish, beige, yellowish) color and smoother texture of the exposed rock outcropping.

(7) Colorow Mountains

This subtype has a subdued, very slightly angular mountainous form with a moderate horizontal line. Colors are the dark muted green tones of the vegetation (pinyon-juniper type) and the beige of the rock. Rock covered by a mottled vegetation pattern gives a slightly coarse texture.

(8) Flattops

This subtype is comprised of high, uplifted flat volcanic strata, deeply cut by narrow river valleys. Line is strongly horizontal on the top, becoming steep to moderately angular in the foothills. Colors range from the dark green of the evergreens to the lighter green of aspen and the interspersed grassy parks. This varied vegetation results in a moderately coarse texture.

(9) Cathedral Bluffs - Douglas Creek

This subtype is characterized by a rolling, angular low mountain form. Horizontal line predominates in the rock strata of Cathedral Bluffs, with angular line occurring in the other hill areas. Colors are the sage green of the vegetation, alternating with the light beige of the earth. The resulting texture is moderately coarse.

When compared with most of the other subtypes of the region, it is evident that the Piceance Creek basin is less notable in terms of strength of form and line, and ranks equally with regard to color and texture variations.

c. Variety Classes

Within the confines of the Piceance Creek basin, there are considerable variations in landform, rockform, vegetation and waterforms. These variations can be defined by a series of variety classes which account for the inherent scenic quality of the landscape. The human aspects will be considered below.

A series of criteria are set forth in Table XIII-1 and were used to differentiate the variety classes (distinctive, common or minimal) which exist in the Piceance Creek basin. It was convenient to identify the distinctive and minimal areas on a map and to assume the remainder are common. Examples of these variety classes are shown in Figures XIII-4 through XIII-7, and a map of variety classes is shown in Figure XIII-8. The cliffs at the mouth of Scandard Gulch are the only distinctive area found on the Tract. Several other distinctive areas are located off-tract; most of these also consist of dominant rockforms. The minimal areas in the study area are quite extensive and cover a considerable portion of the Tract and nearby areas to the west. These areas have been chained within the past 10 years.

3. Human Factors

In order to account for the human aspects of the visual experience in this scenic quality analysis, the methodology includes a measurement of the relative importance of use areas, water bodies and travel routes, viewers' concern for scenic values, and the distance from which the landscape is viewed. The rationale used to account for each of these factors will be discussed below.

Table XIII–1 VARIETY CLASSES DETERMINATION*

	DISTINCTIVE	COMMON	MINIMAL
LANDFORM	Cliffs on valley sides Highly eroded slopes	Moderately steep valley sides, flat ridge tops and flat valley bottoms	Extensive flat ridge tops or valley floors
ROCKFORM	Rock features which stand out on landform Unusual rock strata exposures	Rock features obvious but do not stand out	Rock features small to nonexistent
VEGETATION	High degree of patterns in vegetation High diversity in plant forms Relatively large stands of trees	Continuous vegetative cover with some degree of pattern Low diversity in plant forms Irrigated meadows	Continuous vegetative cover with little or no pattern Chained or sprayed areas Non-irrigated valley bottoms
LAKES, PONDS	Irregular shorelines Greater than one acre in size	Regular shorelines Less than one acre in size	No lakes or ponds
STREAMS, SPRINGS AND SEEPS	Springs and seeps which form ponds Perennial streams Large volume	Springs and seeps which do not form ponds Ephemeral streams Low volume	No streams, springs or seeps

* Only one of the criteria had to be met for an area to be classed as Distinctive, whereas two or three criteri had to be met for an area to be classed as Minimal. This allowed Distinctive areas to be readily identifie while Minimal areas needed considerably more factors for them to be so classified.

Figure XIII–4 MINIMAL VEGETATION AND LANDFORM

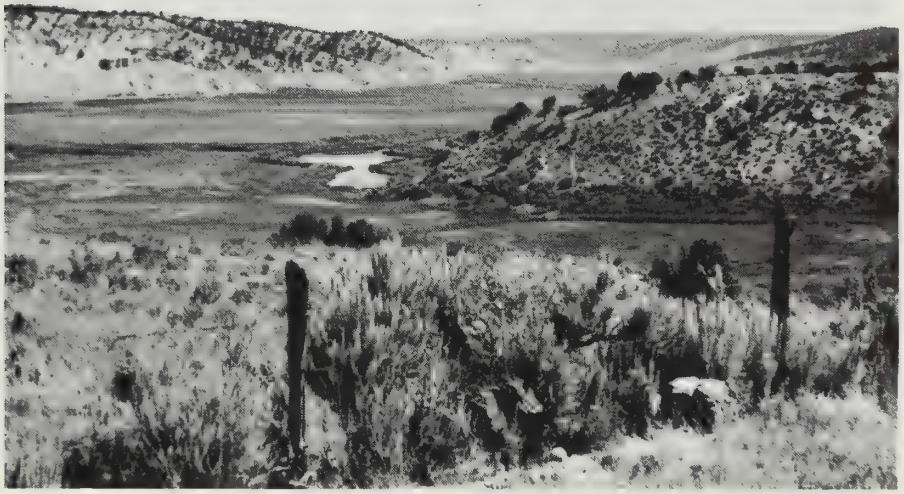


Figure XIII–5 COMMON LANDFORM
AND DISTINCTIVE WATERFORM

Figure XIII–6 DISTINCTIVE ROCKFORM

Figure XIII–7 COMMON VEGETATION

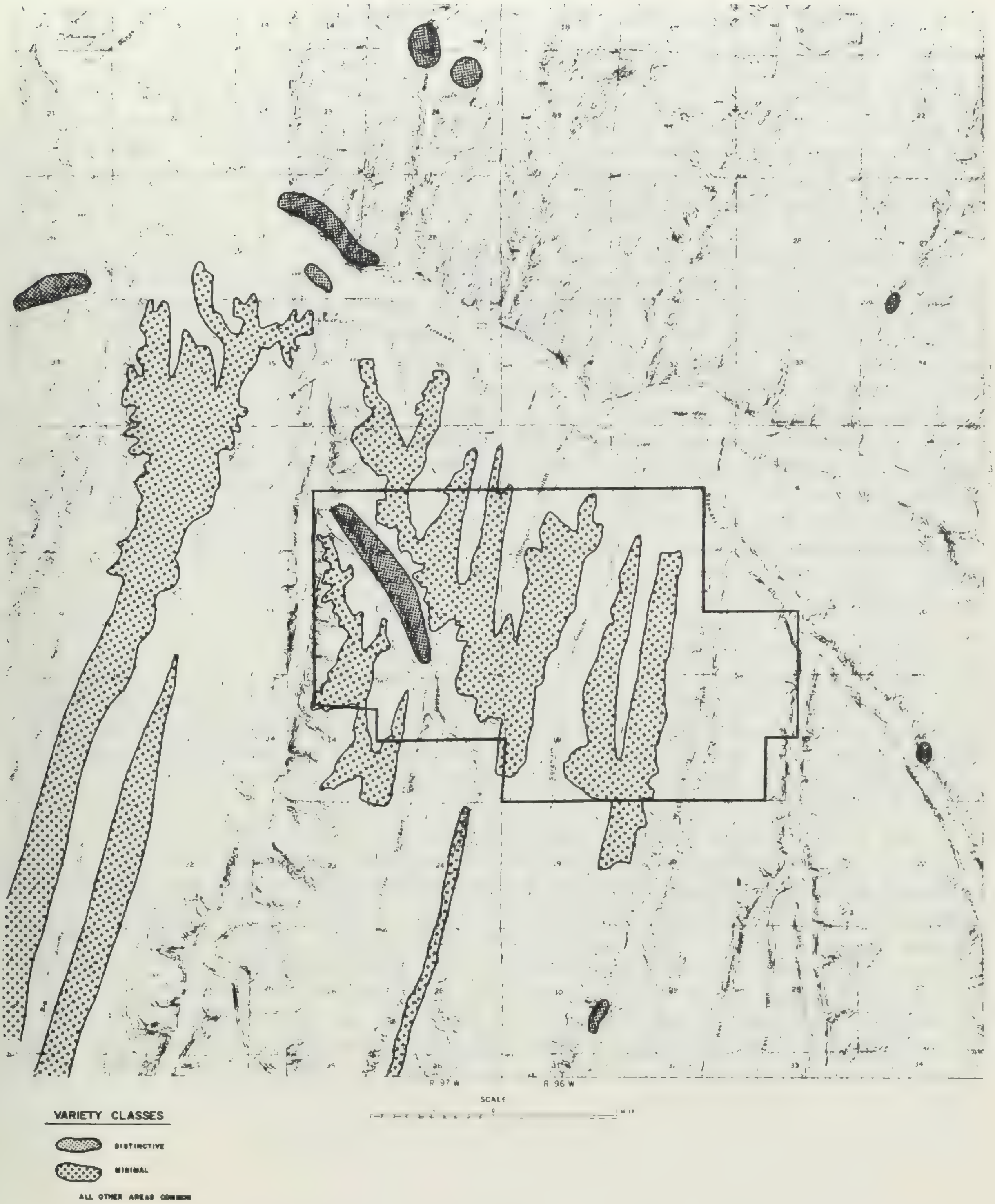


Figure XIII–8 VISUAL QUALITY ANALYSIS VARIETY CLASSES

a. Importance of User Areas

User areas such as roads, trails, overlooks, camp sites, ranch headquarters, cow camps, ponds and streams are rated as being of primary or secondary importance based on size, volume of use, duration of use, recreational use and local importance. In this study user importance was considered only in terms of use factors within the Piceance Creek basin. These factors are shown in Table XIII-2. A map of primary and secondary user areas identified in the study area is shown in Figure XIII-9. User volume, duration of use, and size were the criteria used to differentiate user areas.

The only travel routes rated as being of primary importance were the Piceance Creek road and the Collins Gulch road. Piceance Creek road is used by local residents, drilling crews and government agency personnel. It is not a scenic highway; in fact, until it was completely paved several years ago, it did not appear on many highway maps. Collins Gulch road serves the employees of a gas absorption plant located north of Tract C-b. All other roads were classed as being of secondary importance due to the lesser traffic volumes and seasonal use. These roads are used primarily by local ranchers for movement of cattle and sheep and by hunters seeking deer and elk. User areas of primary importance are the ranch headquarters, all of which are situated on the Piceance Creek road. All other use areas and water bodies were classed as secondary in importance due to the low volume of general use and low recreational use.

b. Viewer Sensitivity Levels

To account for the concern for scenic values which the users of the Piceance Creek basin have, a matrix was developed showing the importance of user areas and an appraisal of the percentage of users having some concern for scenic values. The matrix is shown in Table XIII-3.

The U. S. Forest Service method bases its concern for scenic values on a percentage of viewers having a major concern for scenic values. The U. S. Forest Service assumes that persons having a major concern for scenic values are those engaged in driving for pleasure, hiking scenic trails, camping at primary use areas, or using lakes and streams for other recreational activities. Minor concern for scenic values is assumed to be held by persons involved in daily commuter driving or hauling forest products or employed in other commercial uses of the forest. On this basis less than 10 percent of all Piceance Creek basin users are estimated to have a major concern for scenic values.

Table XIII–2 USER AREA CRITERIA

	PRIMARY IMPORTANCE	SECONDARY IMPORTANCE
TRAVEL ROUTES	High use volume	Low use volume
	Major access road	Project road
Roads	Long use duration	Short use duration
Trails		
USE AREAS	Large size	Small size
	Long use duration	Short use duration
Overlooks	High use volume	Low use volume
Camp areas		
Ranch headquarters		
Cow camps		
WATER BODIES	High recreation use	Low recreation use
Ponds		
Streams		

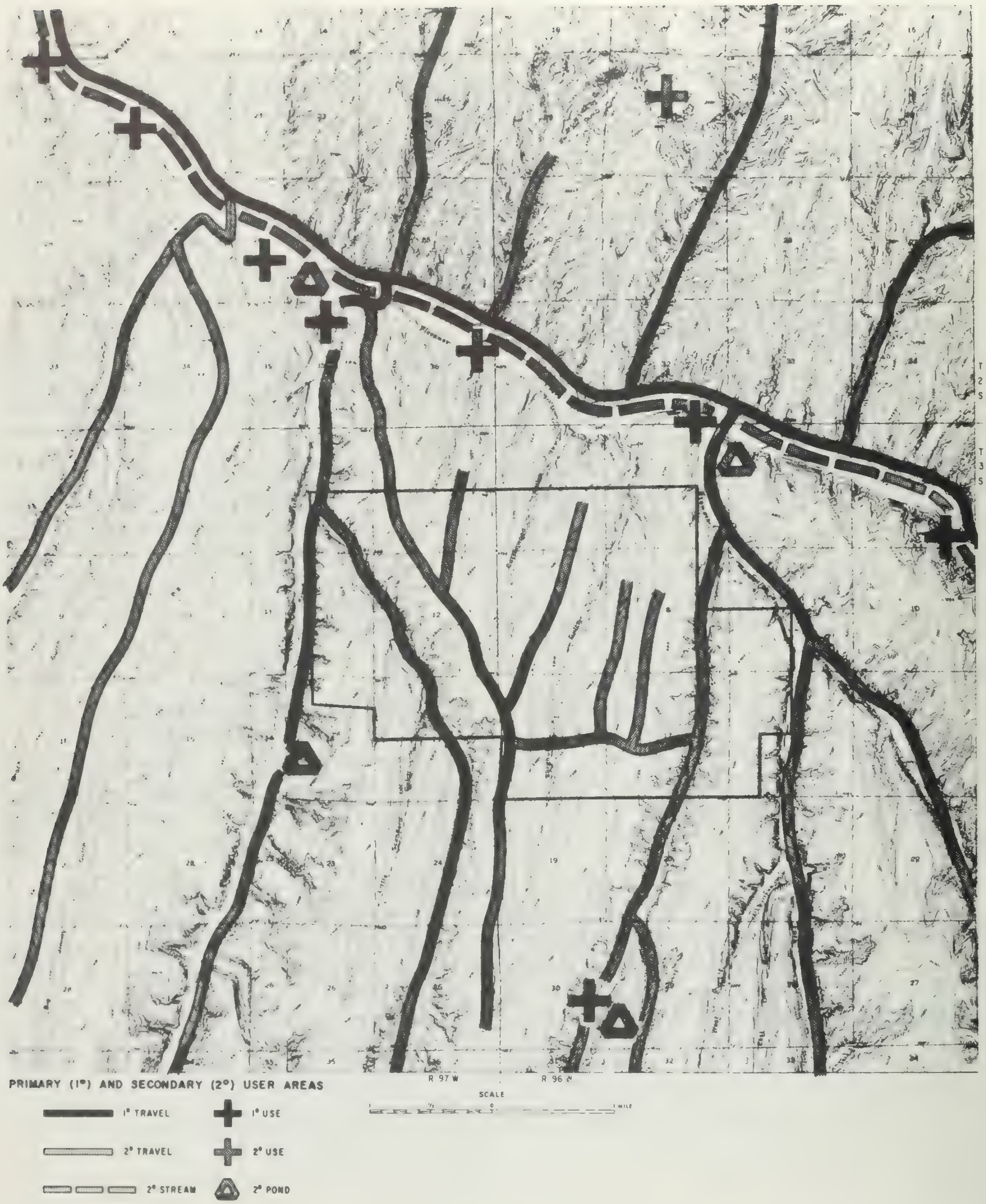


Figure XIII–9 VISUAL QUALITY ANALYSIS
USER AREAS

Table XIII–3 VIEWER SENSITIVITY LEVELS

User Area	Viewer Sensitivity Levels		
	1	2	3
Primary	At least 1/4 of users have SOME concern for scenic values (PICEANCE CREEK ROAD AND RANCH HEADQUARTERS)	Less than 1/4 of users have SOME concern for scenic values (COLLINS GULCH ROAD)	
Secondary	More than 3/4 of users have SOME concern for scenic values.	Between 3/4 and 1/4 of users have SOME concern for scenic values (ALL OTHER INTENSIVE STUDY AREA ROADS)	Less than 1/4 of users have SOME concern for scenic values (AREAS NOT SEEN FROM ANY USER AREA)

Given this assumption there are no primary sensitivity levels. Since no hard data was available on which to base this 10 percent estimate, a liberal approach was taken by assuming that users had some concern for scenic values. This permitted all sensitivity levels to be represented.

The Piceance Creek road and the ranch headquarters were placed in sensitivity level 1. It was assumed that at least 25 percent of these users had some concern for scenic values. Collins Gulch road was judged to have fewer users concerned about scenic values and thus was placed in sensitivity level 2. All other roads in the study area were also placed in sensitivity level 2. While they are of secondary importance, a considerable number of users (deer hunters and local ranchers) were assumed to have some concern for scenic values while engaged in their primary goals. All areas not seen from any travel route or use area were placed in sensitivity level 3, the lowest level.

c. Distance Zones

One method of determining how different sections of the study area are viewed by users is to define distance zones, view the landscape from each user area, and prepare a distance zone map for each user area. The criteria used in defining each distance zone is shown on Table XIII-4. In conjunction with the distance zone mapping, sensitivity levels were determined for each area. All distance zone maps were overlayed and sensitivity levels were used to set priorities in developing the composite distance zone/sensitivity level map shown in Figure XIII-10. In all cases the most restrictive sensitivity level was used in the composite map.

d. Sensitivity Classes

The final step in depicting the sensitivity classes which exist on the Tract is to overlay the variety class map with the distance zone/sensitivity level map. The U. S. Forest Service method is designed to produce a final map showing quality objectives and recommending management methods to accomplish these objectives. In this study, the quality objectives have been changed to sensitivity classes as shown in Table XIII-5. A matrix developed by the U. S. Forest Service was used to arrive at the sensitivity class map. This matrix is shown in Table XIII-6. The map of sensitivity classes illustrated in Figure XIII-11 depicts the baseline scenic quality of the intensive study area. Guidelines for visual management of these sensitivity classes are discussed below.

Table XIII–4 DISTANCE ZONE CRITERIA

	Foreground	Midground	Background
Distance (miles)	0 to 1/4-1/2	1/4-1/2 to 3-5	3-5 miles to infinity
Sight capacity	Detail ⟷		No detail
Object viewed (example)	Rock point	Entire ridge	System of ridges
Visual characteristics	Individual plants and species	Texture and Form (conifers/ hardwoods)	Patterns (light and dark)

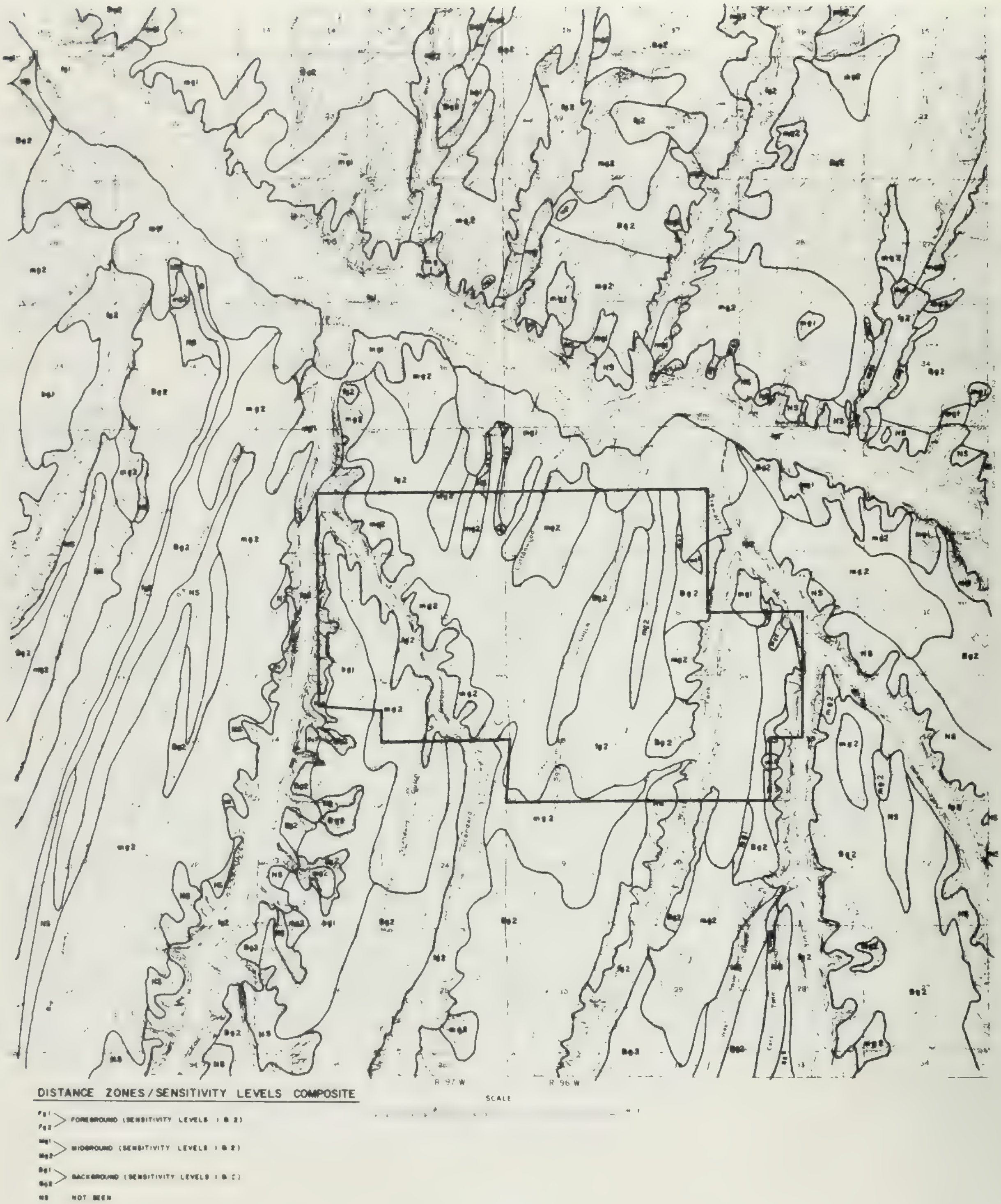


Figure XIII–10 VISUAL QUALITY ANALYSIS DISTANCE ZONES/SENSITIVITY LEVELS

Table XIII–5 SENSITIVE AREAS – QUALITY OBJECTIVES COMPARISON

Sensitivity Class	USFS Visual Quality Objective	Degree of Acceptable Change
A	Retention	Should not be evident
B	Partial Retention	Should be visually subordinate
C	Modification	May be visually dominant but must possess visual characteristics of natural landscape.
D	Maximum Modification	May be visually dominant but must possess visual characteristics of natural landscape when viewed as background.

Table XIII–6 SENSITIVITY CLASS MATRIX *

Variety Class	Distance Zone/Viewer Sensitivity Level						
	Foreground, level 1	Midground, level 1	Background, level 1	Foreground, level 2	Midground, level 2	Background, level 2	Not Seen level 3
Distinctive	A	A	A	B	B	B	B
Common	A	B	B	B	C	C	D
Minimal	B	B	C	C	C	D	D

* Sensitivity Classes

A
B
C
D
$\downarrow$ Decreasing Sensitivity

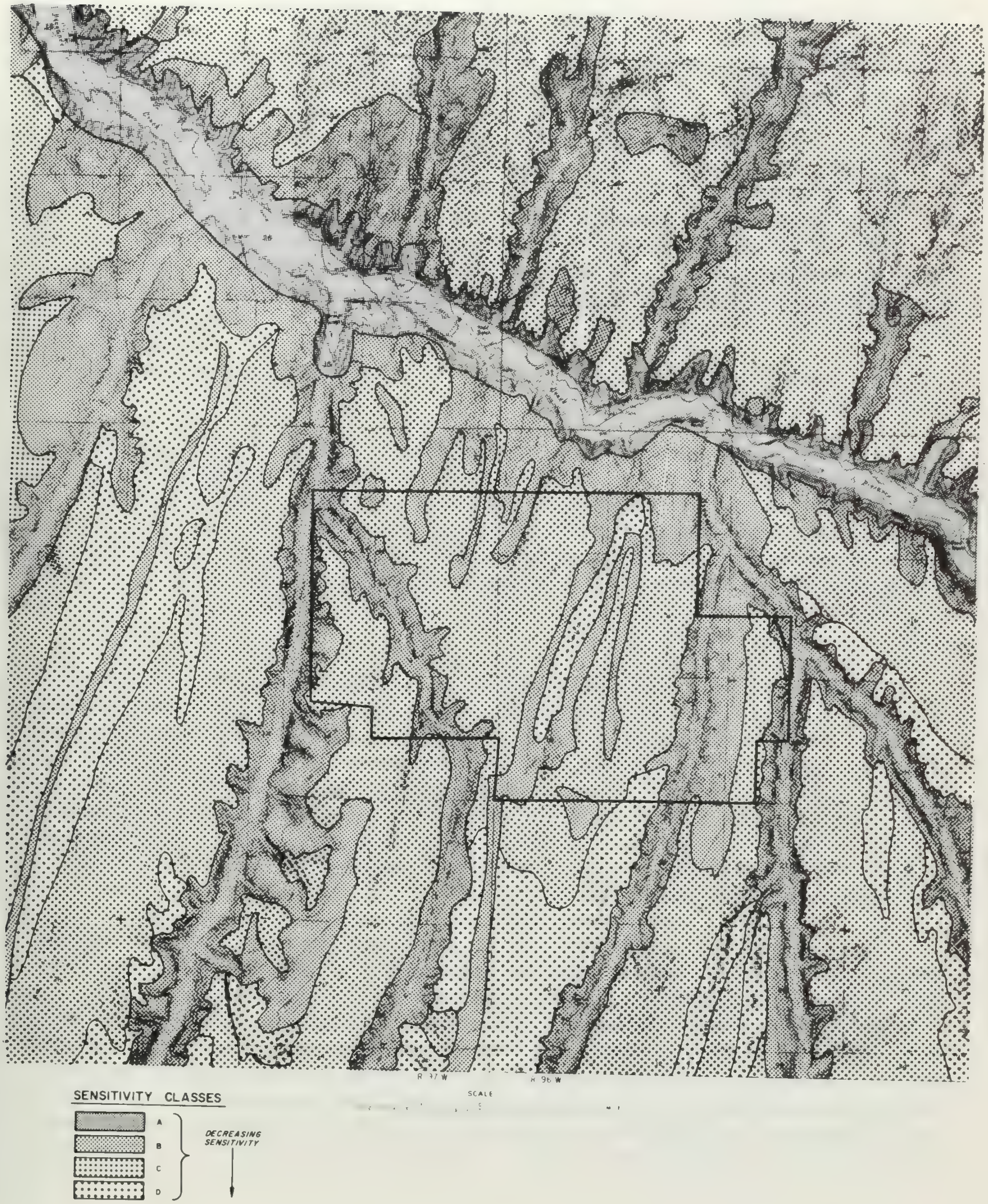


Figure XIII—11 VISUAL QUALITY ANALYSIS SENSITIVITY CLASSES

4. Visual Management Guidelines

The U. S. Forest Service has developed management guidelines for retaining the scenic quality of lands under its control. The C-b Shale Oil Project will use these same visual management guidelines in all planning, construction, reclamation and mining operations. Planned activity on the Tract will not affect areas of high visual sensitivity. In the event that development activities must take place in areas of high visual sensitivity, these activities will be designed to minimize the visual impact of the activity. The level of visual sensitivity of each area proposed for development will be one of several criteria (ecological, economic, hydrological, meteorological, etc.) used in planning and construction of Tract activities. The level of visual sensitivity of the affected area will be a factor in determining design modifications necessary to minimize visual impact.

The visual management guidelines for each sensitivity class are given below:

Class A - Development activities may only repeat form, line, color and texture which are frequently found in the landscape. Changes in their size, amount, intensity direction, patterns, etc., should not be evident. Reduction in form, line, color and texture contrast due to development should be accomplished either during construction or immediately thereafter by such means as seeding vegetation clearings and cut-and-fill slopes, hand planting large plant stock or painting structures.

Class B - Development activities may repeat form, line, color or texture common to the landscape. Changes in size, amount, intensity, direction, pattern, etc., should remain visually subordinate to the landscape. Activities also introduce form, line, color or texture which are found infrequently or not at all in the landscape, but they should remain subordinate to the visual strength of the landscape. Reduction in form, line, color and texture contrast due to development should be accomplished as soon after construction as possible, but no more than one year later.

Class C - Development activities may visually dominate the original landscape; however, activities of vegetative and land form alteration must borrow from naturally established form, line, color and texture so completely and at such a scale that visual characteristics are those of the natural landscape. Additional parts of these activities such as structures and roads must remain visually subordinate to the proposed composition. Activities which involve the introduction of facilities such as buildings, signs, roads, etc., should borrow from

the existing forms, line, color and texture so completely and at such a scale that the visual character is compatible with the natural landscape. Reduction in form, line, color and texture contrast due to development should be accomplished in the first year or at a minimum should meet existing regional guidelines.

Class D - Development activities may dominate the landscape; however, when viewed as background, the visual characteristics must be those of the natural landscape. When viewed as foreground or middle ground, they need not borrow from the natural form, line, color and texture. Alterations may also be out of scale or contain incongruent detail when viewed as foreground or middle ground. Introduction of additional parts of these activities such as structures and roads should remain visually subordinate when viewed as background. Reduction of contrast in form, line, color and texture due to development should be accomplished within five years.

5. Conclusions

The Piceance Creek basin was found to have low scenic value when compared to the other landscape types of the region. It contains marginal strength of form and line when compared to such areas as the Book Cliffs, Roan Cliffs, Grand Mesa and the Flattops. It rates about equally with these with regard to color and texture. On a regional basis the Piceance Creek basin has an extremely low visual character.

The scenic values of the Piceance Creek basin were evaluated solely within the context of the basin itself. A four level rating scale was developed based on the U. S. Forest Service Visual Management System. Within the context of the Piceance Creek basin proper, the only Class A area near Tract C-b is the Piceance Creek road corridor. The Tract is located in an area determined to be of sensitivity Classes B and C. The sensitivity Class B areas include the principal drainage cutting through the Tract. The Class C areas comprise the chained regions, which cover some 50 percent of the Tract. The bottom of the on-tract portion of Sorghum Gulch was rated as Class D since it is not visible from any user area.

The assumptions made in this study were designed to maximize the scenic values which do exist in the Piceance Creek basin. As stated earlier, these values are marginal when compared to those existing in contiguous areas of Western Colorado. The final map is a liberal interpretation of the Piceance Creek basin's scenic values, since most users' cone-of-vision does not expose them to many of the side gulches which contain the basin's distinctive landscapes. This was most evident to the field investigators who had considerable familiarity with the area but still found access to much of it solely as a result of doing this study.

It should be emphasized that primarily this methodology accounts for scenic qualities seen by the majority of basin users. It does not account for small isolated areas that an individual hiker or hunter might encounter when traveling off established travel routes. Such areas are subject to extremely individual preferences that no methodology designed to study regional scenic values can accommodate.

B. Archaeological Values

1. Introduction

A detailed baseline study of the cultural resources of Tract C-b has been conducted under the direction of C. H. Jennings of the Laboratory of Public Archaeology at Colorado State University. The purpose of his investigation was to: identify sites of past human activity in the Tract area, relate these sites to contemporaneous activities in the region, and assess the scientific value and historical significance of each site.

Previous archaeological work in the Piceance Creek basin, including a reconnaissance of the Tract, was carried out by Colorado State University in cooperation with Thorne Ecological Institute of Boulder, Colorado during the summer of 1973. That work was done as part of the Regional Oil Shale Study for the Colorado Department of Natural Resources (ROSS #5). In addition, other field work in the Piceance Creek basin has been carried out by the University of Denver and Southern Colorado State College in connection with other oil shale projects.

A majority of the detailed field work on Tract C-b was conducted in August 1974. A total of 2640 acres were intensively examined. Examination of drill sites and other potential disturbed areas that were not included in the initial studies have been conducted since then. Field work was conducted under Federal Antiquities Permit 70-CO-055.

A quadrat system of quarters of public land survey sections was used for the detailed field survey of the Tract. The quadrats were laid out in a checkerboard pattern and each sample quadrat was examined by three or four investigators making a series of sweeps. All sites encountered were recorded on Archaeological Survey site inventory forms and these have been included in the Quarterly Data Reports to the AOSS. None of the sites had enough artifacts to warrant any attempt at systematization or standardization. All the artifacts were catalogued in the Colorado State University system and are stored at Colorado State University. Figure XIII-12 shows the areas surveyed and identifies the sites.

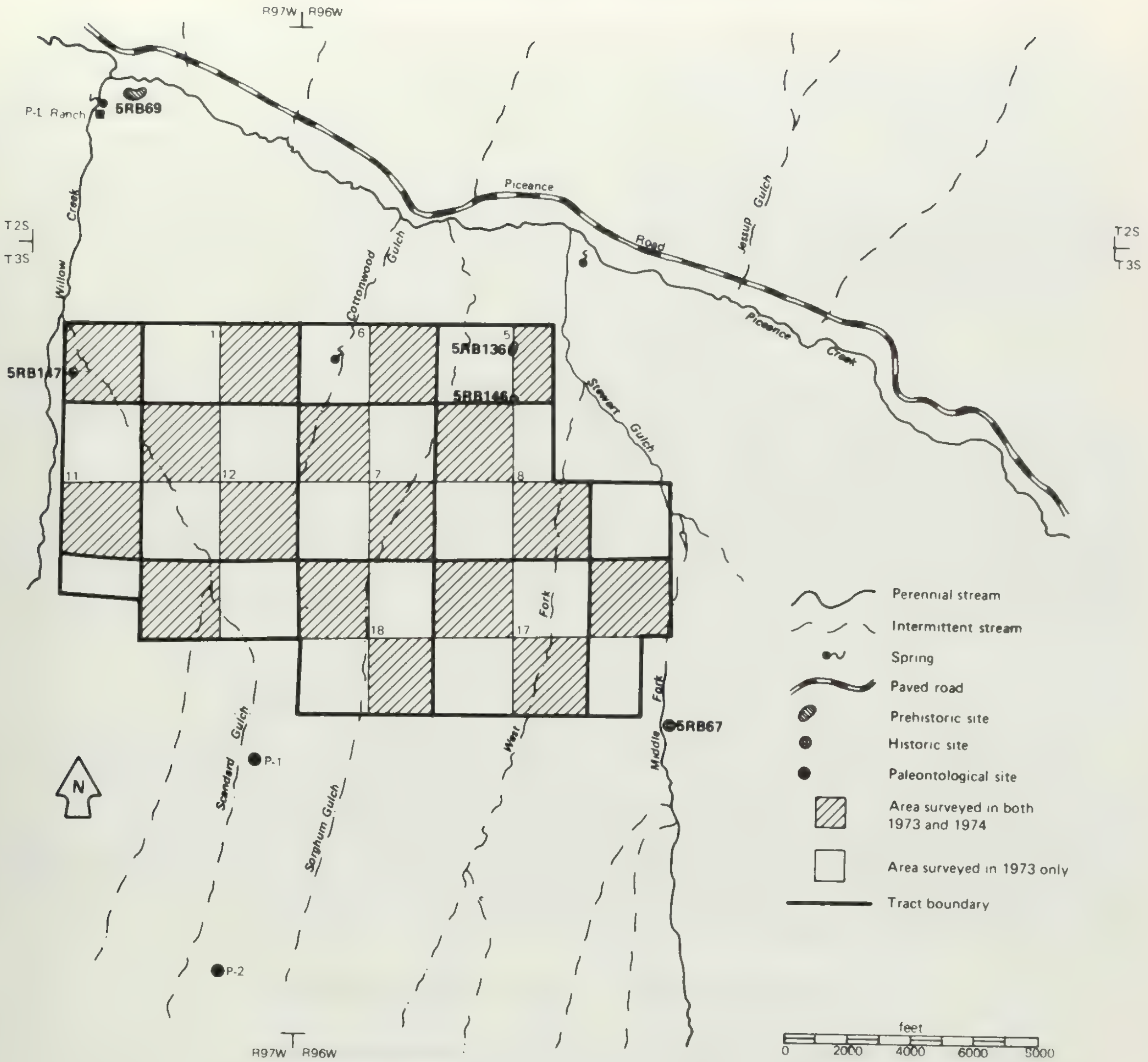


Figure XIII–12 ARCHAEOLOGICAL AND PALEONTOLOGICAL SITES, TRACT C-b AND VICINITY

a. Environmental Background

The environmental setting of the Piceance Creek basin is discussed in detail in the preceding sections of this volume. The setting indicates that some elements of the region would have encouraged at least seasonal use of the area in the past. Surface water is available throughout the year in stream valleys and raw materials, with the exception of stone tool materials, are readily available. Generally, the Piceance Creek basin is similar to other parts of the Colorado plateaus, which have had a lengthy history of human occupation.

b. Paleontological Resources

Prior to this study, it was believed that the Piceance Creek basin did not have any paleontological resources. However, geological workers discovered mammalian fossils at two sites in the vicinity of Tract C-b. Dr. Peter Robinson, Director of the University of Colorado Museum, has reported that one of the fossils is an as-yet-unidentified mammal and the other apparently the head of a femur of an Uintathere, probably *Uintatherium*. The sites are identified on Figure XIII-12.

2. Synopsis of Region's Cultures

a. Paleoindian Period, Prior to 7000 B.C.

There is no known evidence of Paleoindian occupation in the Tract region. The absence of evidence of either proboscideons or bison in the Piceance Creek basin's fossil record may indicate that the resources which would have attracted Paleoindians were either not present or not present in large enough numbers to have met the hunters' subsistence requirements.

b. Archaic Period, 7000 B.C. - 1776 A.D.

The earliest human occupation of the Piceance Creek basin dates from 7000 B.C., and the intensity of occupation increased steadily over the next several thousand years. The basin would have been ideal for people pursuing an Archaic mode of subsistence. A wide variety of plant and animal resources would have proved attractive.

In neighboring regions, a mixed horticultural and foraging subsistence system, termed the Fremont Culture, was practiced. None of the horticultural practices, pottery or art, is evident in the Piceance Creek basin. Thus, it seems probable there was no permanent occupation of the basin. Cool to cold soils and short growing seasons are the principal restrictive factors; therefore, corn cultivation would have been a highly unreliable source of subsistence. The Fremont people may have come into the region in search of game and wild vegetable products, but their presence would not be separable from that of other contemporaneous groups using the region for the same purpose.

c. Protohistoric Period, 1776 A.D. - 1868 A.D.

The Escalante-Dominquez expedition gives the first evidence of the use of the region surrounding the Tract by an ethnographically known group, the Ute Indians. Escalante, however, gives no information on the way of life of the Northern Utes.

In the Piceance Creek basin, several sites have been located which may be the remains of the Ute occupation of the region. All have produced preindustrial artifactual material, but no metal or other goods which would indicate contact with Euro-Americans. Sites on or near the Tract are either definitely tied to the Euro-American occupation of the area, or have no clear ethnographic relationships.

d. Euro-American Period, 1868 A.D. - Present

The American Indian occupants of the region were the Ute Indians, who remained there until forcibly removed in 1879. Upon expulsion of the Utes, Euro-American settlers began to occupy the area. Early settlers raised sheep and cattle in the basin, and the subsequent overgrazing had considerable effect on the landscape.

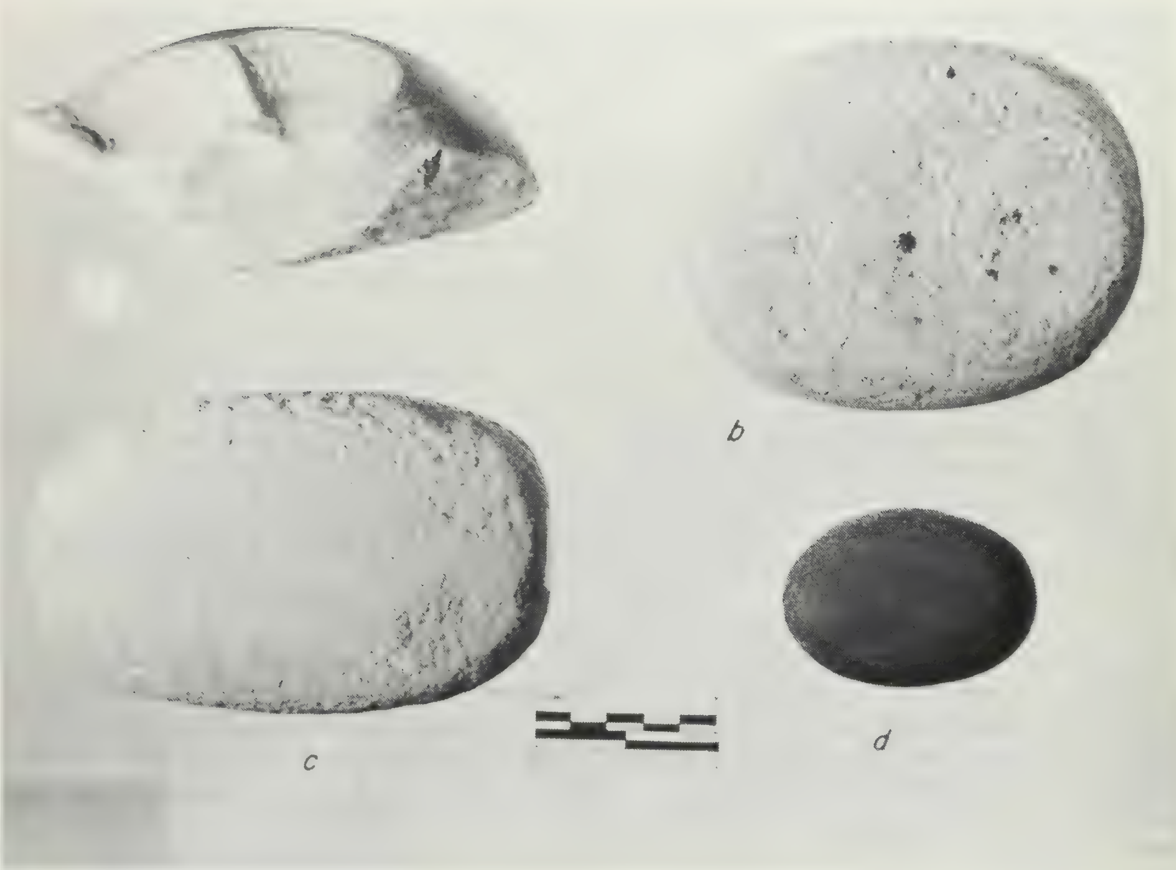
3. Cultural Resources - Prehistoric Sites

Four prehistoric archaeological sites have been recorded on the Tract and in immediately adjacent areas, as shown on Figure XIII-12. The Tract has been intensively examined for antiquities, but in the adjacent areas site discovery has been the result of chance encounters rather than systematic survey. Photographs of artifacts discovered at recorded sites, as well as photos of isolated finds, are shown in Figure XIII-13 and Figure XIII-14. The recorded sites are as follows:

a. Site 5RB69

This site is on the northern edge of an alluvial terrace on the south side of the Piceance Creek valley, as shown on the map in Figure XIII-12 above. It faces north, 27 meters above the flood plain of Piceance Creek, and is relatively distant from the bluffs. The area has been disturbed to a depth of 5 centimeters by livestock walking over the site, but there is no evidence to indicate the presence of any stationary objects such as fire pits, housefloors or storage structures. There is a good possibility that local residents have collected at least some of the artifactual material from the surface.

Six flakes comprise the total artifact yield on the site. The yield is too limited to permit any assignment of the site to a time period other than Protohistoric or earlier.



a. Artifact No. IF114
b. Artifact No. IF115
c. Artifact No. IF116
d. Artifact No. IF118

Figure XIII–13 CORE AND HAND STONES FROM TRACT C-b

a. Artifact No. 5RB136.1
b. Artifact No. 5RB146.1
c. Artifact No. 5RB146.3
d. Artifact No. IF109
e. Artifact No. IF112
f. Artifact No. IF113
g. Artifact No. IF110
h. Artifact No. IF111

Figure XIII—14 SMALL CHIPPED STONE ARTIFACTS FROM TRACT C-b

b. Site 5RB136

The site is on the crest of the ridge between Stewart Gulch and Sorghum Gulch as shown on Figure XIII-12. The site is on a fairly level ground and elevated above the surrounding terrain. It is now located in a dense stand of pinyon-juniper.

There are no visible features present on the site even though the site is relatively undisturbed. However, a few fragments of shattered bone which had been exposed to intense heating were found. The artifact yield was small. Only seven waste flakes and a single tool were found. The tool (5RB136.1) is a bifacially flaked object with no modifications, such as notches, of the blade margins.

The absence of diagnostic artifacts from the inventory makes determination of the age of occupation or the cultural affinitives of the occupants impossible.

c. Site 5RB146

The site occupies about the same topographic position as 5RB136, as can be seen from Figure XIII-12 above. The exception is that there is a tributary drainage to Stewart Gulch which has incised itself into the eastern flank of the ridge.

The site has been extensively disturbed by the chaining of the ridge tops, and its scientific and cultural values have been destroyed. Only three waste flakes could be found in the area, indicating rather limited use of the site. Two projectile points (5RB146.1 and 5RB146.3) were found. They are similar to others found in the region. One projectile point is slightly asymmetrical; one blade margin is straight, while the other is convex. No dates were assigned to this type. A single scraper fragment was also found at the site. The site is assigned to the Archaic Period and falls near the middle of the period.

d. Site 5RB147

The site is in a ridge-top situation and has a good view of Scandard Gulch and the Tract area to the east, as shown on Figure XIII-12. Because this area has been subjected to chaining, much of the site has been extensively disturbed. The site produced four waste flakes and a small fragment of knife blade or projectile point. The tool is too fragmentary to be compared with materials from other sites.

4. Cultural Resources - Euro-American Sites

Site 5RB67 is located on an alluvial fan across the bottom of Middle Fork Stewart Gulch, as shown on Figure XIII-12. It consists of a cement-chinked log cabin, a dugout and a thin scatter of historic trash. An abandoned irrigation ditch also crosses the site.

The cabin is in a bad state of repair, though there are no signs of disturbance of the deposits. Materials collected include beer cans dated from the late 1940's and early 1950's, as well as pottery and glass shard. The last significant use of the site appears to have been 25 years ago. Nails used indicate the cabin was probably built no earlier than the 1920's.

5. Isolated Finds

a. Projectile Points

Three projectile points (1F109, 112 and 113) collected from the Tract area could not be associated with any other artifact materials. These artifacts were probably lost or discarded at the places where discovered.

b. Other Chipped-stone Tools

A simple flake (1F110) was found that has been retouched for a short distance along one margin. It probably served as a knife rather than scraper.

One tool which was found is relatively rare in the Piceance Creek basin. It is a combination tool that has an acutely retouched working edge along one of its longer edges and a very steeply retouched working edge on one of the shorter edges. The tool (1F111) is a combination side-and-end scraper which also has an intentionally produced graver tip.

A core (1F114) was found from which flakes, for manufacture into tools, were removed. The sharp edge formed where the scars meet shows no evidence of wear. This would indicate that the specimen had not been used for another function. The object is not suitable for dating.

Another very small fragment of a bifacially chipped tool was found but it was too small to identify.

c. Ground Stone Tools

A subrectangular mano, or hand stone (1F115) used in the processing of nuts and seeds into meal, was found. It is made of quartzite cobble, has two working faces, and is about the proper size for one-handed use.

Another mano (1F116) has only one working face.

Another tool (1F118) is a small water-worn cobble of some dense, fine-grained, black material. It shows no manufacturing or use marks, but does have prominent flattened areas or facets on the two faces. It has no features of note and has no diagnostic value.

6. Summary and Interpretation

Four prehistoric sites (three within the Tract and one outside), one historic site outside the Tract boundary, and several isolated artifacts comprise the cultural resources found on the Tract.

The time period represented by the sites and artifacts falls roughly between 5000 B.C. and the early 1950's. This spans the Archaic and Euro-American periods. The area was first used by hunters/gatherers and then by pastoralists who raised sheep and cattle. From the foregoing information, it is assumed that the Tract was only lightly occupied. The chaining of the pinyon pine-juniper probably had deleterious effects on the fragile archaeological sites and evidence of prehistory activity was possibly destroyed by that range improvement program.

No factor in the cultural resource inventory has been found which would prevent further development of the mineral resources on the Tract, according to the investigating archaeologist's report.

7. Conclusion

In summary, sites 5RB136 and 5RB146 are the only sites deemed worthy of future consideration in the development of Tract C-b. These sites will be further investigated prior to any developments which would disturb them. The other recorded sites in and near the Tract will require no further study as they either have very little potential or have already been destroyed by human or natural factors.

XIV. ENVIRONMENTAL SETTING OF OFF-TRACT CORRIDORS

In connection with the commercial development of the Tract, certain off-tract activity will occur in connection with transportation of water, products and by-products. These activities are described in detail in Volume I. In order to minimize environmental effects, the Lessee has examined numerous alternative routes for each activity with the objectives of consolidating all activity in a limited area and using existing corridors when possible. With those objectives in mind, the Lessee has conducted environmental studies of several possible corridors which may be used in connection with Tract development. Those corridors are located as shown on Figure XIV-1 and described in the following discussion.

Multi-purpose Spur Corridor. This corridor would extend southerly from the plant site on the Tract, and along Scandard Ridge, about 14 miles to the La Sal pipeline, which will run from the Colony plant to southern Utah. This spur is the most probable path for the product pipeline, by-products pipelines and the water-supply pipeline. The product pipeline from the Tract would connect with the La Sal pipeline at the southern end of the Multi-purpose spur. The by-product and water pipelines would continue easterly in the La Sal corridor to the Colony property and then south down Parachute Creek to Grand Valley. From the point of connection of the Multi-purpose Spur Corridor with the La Sal pipeline, existing corridors would be followed. A secondary service road would parallel the corridor.

Alternate Water Corridor. This corridor extends from the Tract to Piceance Creek and then easterly on the north side of the creek to Fourteenmile Creek. It would then proceed easterly on Fourteenmile Creek to Sheep Creek and then northerly to the White River. This corridor would only be used if water were not available from the Colorado River.

Transportation and Alternate By-products Corridor. This corridor extends from the Tract to Piceance Creek road, then easterly along that highway to the junction with State Highway 13/789 at the Rio Blanco Store, and then southerly on Highway 13/789 to Rifle. This corridor is the primary access and transportation corridor for construction equipment and employees. It also would be an alternate corridor for by-products if they are transported by truck rather than by pipeline.

Environmental investigations of these corridors were conducted by the Lessee in 1975, with emphasis on the Multi-purpose Spur Corridor. Included were studies of aquatic biology, hydrology, avifauna, wildlife, vegetation, scenics, soils and archaeology; a summary of these studies is contained in this section. Environmental studies for the La Sal pipeline corridor and the Parachute Creek corridor can be found in the Draft Environmental Impact Statement for the Colony Development Operation, prepared by the Bureau of Land Management, U. S. Department of the Interior.

PROPOSED CORRIDORS:

—·— Preferred multi-purpose spur corridor (shale oil, by-products, water)

--- Preferred water and by-products pipeline corridor

—··— Preferred road and alternate by-products corridor

········ Alternate water pipeline corridor

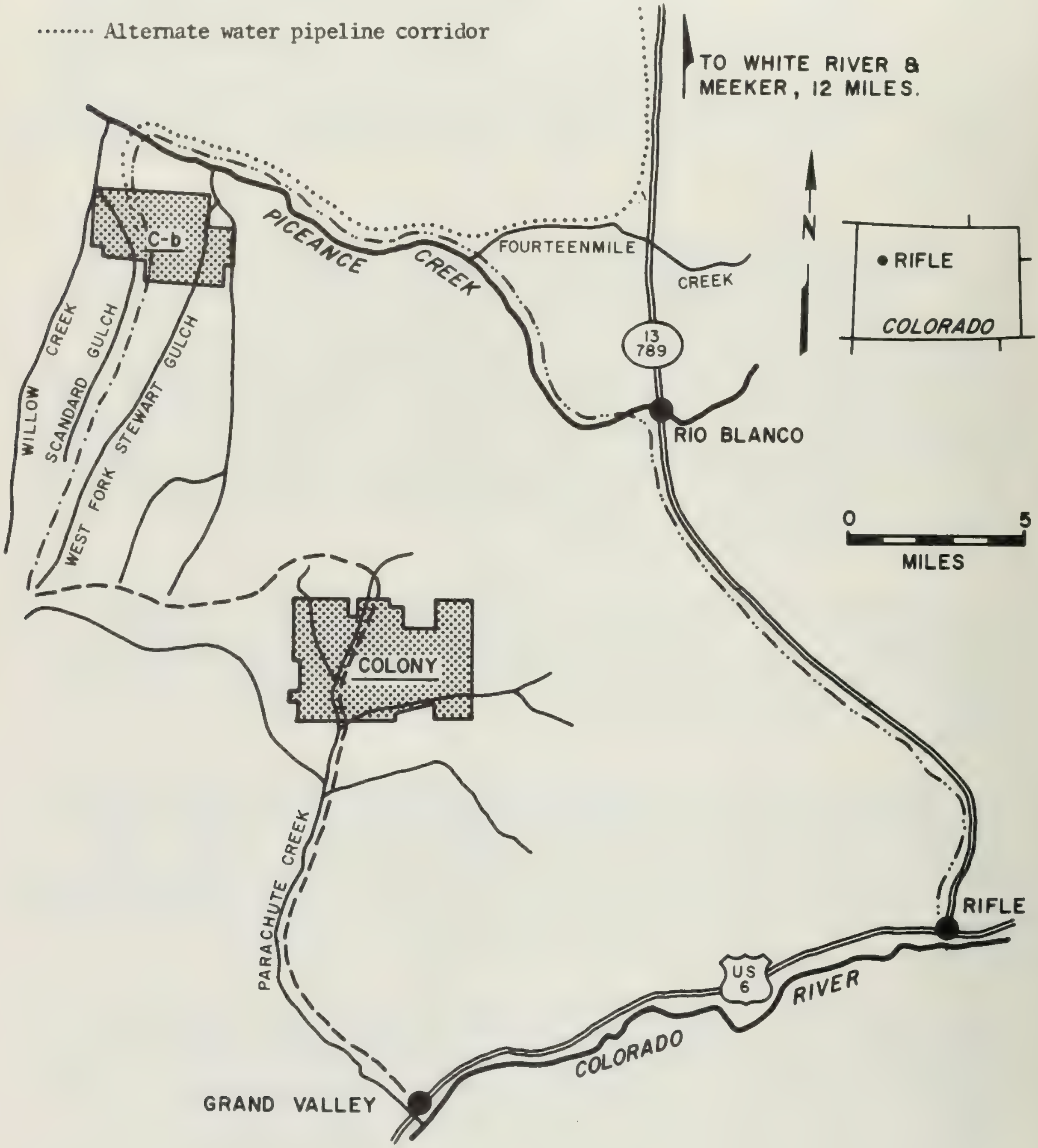


Figure XIV–1 PROPOSED CORRIDOR ROUTES

A. Aquatic Biology

1. Introduction

The purpose of this investigation was to collect baseline data on biological populations in streams which cross or closely parallel the proposed Multi-purpose Spur Corridor. Periphytic algae, benthic macro-invertebrates and fish were sampled to determine species present and their relative abundances. Physical data were collected to evaluate present habitat conditions.

Field investigations were performed in the drainages of Scandard Gulch, West Fork Stewart Gulch and East Willow Creek. Scandard Gulch and West Fork Stewart Gulch were dry at the time of the field investigations, and thus only physical data on channel morphology and substrata were collected. Biological and physical data were collected on the permanent waters of Willow Creek and Redd Cow Camp Reservoir. This reservoir is a small spring-fed, manmade impoundment located in West Fork Stewart Gulch.

Three sampling sites were established on each of the three streams and two sampling sites were used for Redd Cow Camp Reservoir, one at the shallow inlet end and one at the deeper outlet end. Locations of these sampling sites are shown on Figure XIV-2.

2. Methods

Sampling stations were initially selected by examination of a USGS, 1:24,000 topographic map. Approximately equal spacing of stations over the studied segments of Scandard Gulch, West Fork Stewart Gulch and Willow Creek was achieved. Exact field locations of stations were chosen to be representative of the segments to be studied.

Field investigations were performed between July 15 and July 19, 1975. Laboratory and field techniques used for data collection and analysis are discussed in the following sections.

a. Physical Characteristics

Three transects running perpendicular to the stream channel were established at each sampling station on East Willow Creek. Transects were spaced at 100-foot intervals, and all physical and biological data were collected within this 200-foot segment. At each transect, the following physical parameters were recorded: width, depth, gradient, bank stability, substrate composition, streamside vegetation type and water surface classification (i.e., riffle or pool). Width and depth were measured with a 100-foot steel tape. Substrate composition was evaluated in the field and defined by category as inorganic (bedrock, gravel, sand, silt, etc.) or organic (detritus, peat, muck). Gradient readings were taken using a hand level and a calibrated pole. Gradient was measured over a 100-foot segment from middle to downstream transect. Bank stability and water-surface classifications were based on subjective judgment; no specific measurements were made.

Substrate composition, dominant vegetation and streambed gradient and width measurements were taken at each station on dry ephemeral streams. Methods employed were the same as used for East Willow Creek.

b. Biological Characteristics

(1) Periphyton

Periphytic algae were collected from representative natural substrates on each transect on Willow Creek and from Redd Cow Camp Reservoir. Periphyton was scraped into vials, preserved in 5% gluteraldehyde and returned to the laboratory for identification and enumeration. Algae were identified to species level where possible. An indication of relative abundance was obtained by observing 20 microscope fields from each sample and recording the species present. A species which was recorded in 16 to 20 fields was considered abundant; in 11 to 15 fields common; in 6 to 10 fields occasional; and in 0 to 5 fields uncommon.

(2) Macroinvertebrates

Macroinvertebrate samples were taken with a standard square-foot Surber sampler at each of three transects at each Willow Creek Station. At each sampling point two Surber samples were taken from representative areas and made into a composite.

Macroinvertebrate samples were taken from Redd Cow Camp Reservoir with an Ekman dredge. Two dredge samples were made into a composite at each of the two stations.

Macroinvertebrate collections were washed and concentrated in a number 30 sieve, placed into collection vials and returned to a laboratory in 5% formalin. Animals were enumerated and identified with standard reference keys to the most fine taxonomic level practical.

Relative abundance and diversity indices were calculated for all samples for this project; the Shannon-Wiener diversity index (d) was used. The Environmental Protection Agency has discussed the value of this index and has provided a basic discussion of its calculation and interpretation. The general formula for the index is:

$$\bar{d} = \sum_{i}^{s} \frac{n_i}{N} \left(\log_2 \frac{n_i}{N}\right)$$

where d = community diversity, n_i = total number of individuals in species "i", s = number of different species and N = total number of individuals.

With the given number of species (s), the maximum diversity (d max)

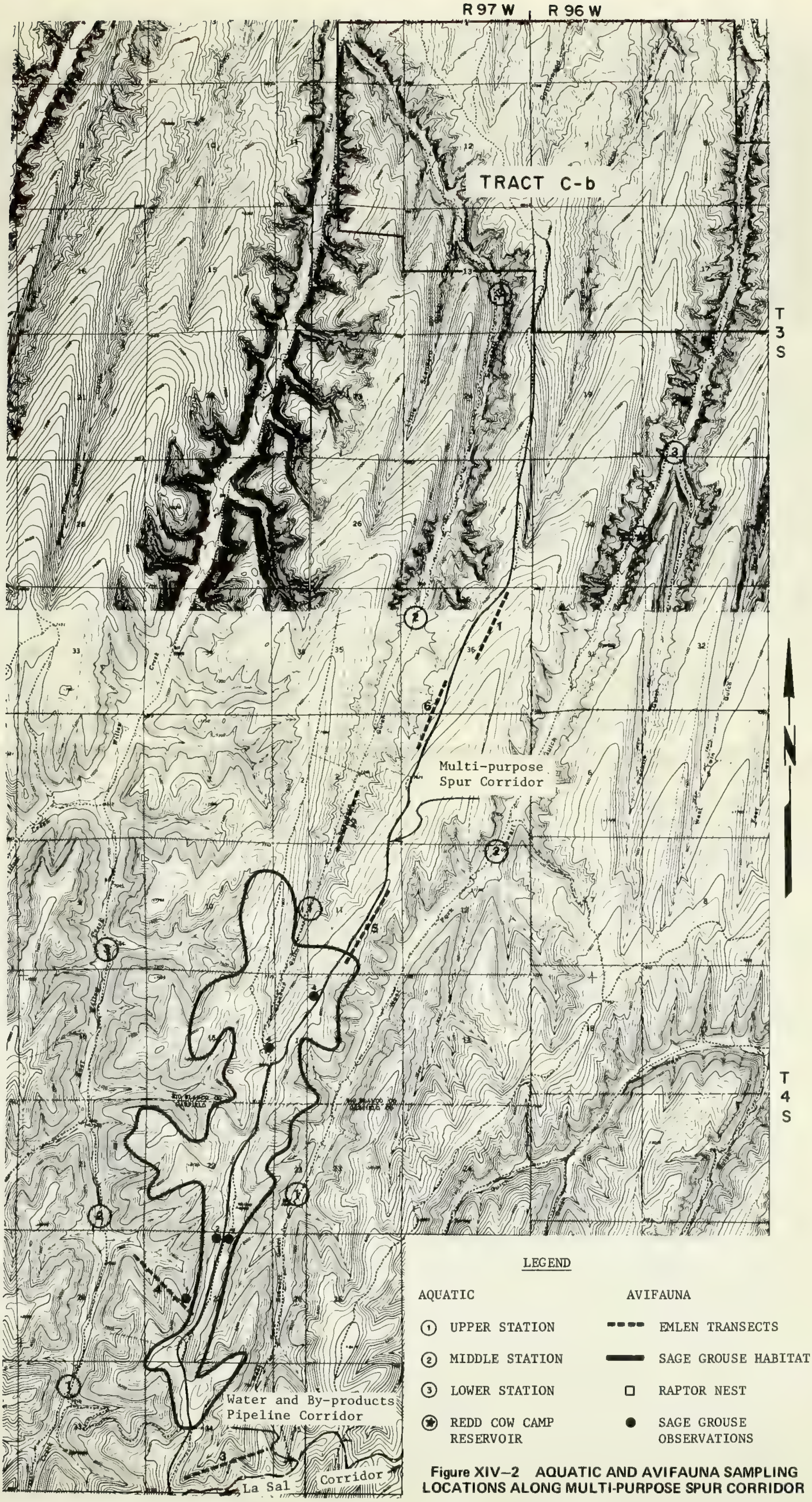


Figure XIV–2 AQUATIC AND AVIFAUNA SAMPLING LOCATIONS ALONG MULTI-PURPOSE SPUR CORRIDOR

would be obtained if all species were represented by an equal number of individuals. This maximum diversity is expressed by the equation: $d_{max} = \log_2 S$. A ratio of the diversity found to the maximum diversity possible is known as equitability (e). Equitability was also calculated for the macroinvertebrate collections.

(3) Fish

Fish were sampled in East Willow Creek with a dip net (1/4-inch mesh). At each station, a 200-foot segment between the upper and lower transects was fished. A minnow seine (1/4-inch mesh) was positioned across the stream at the lower station and the dip nets were manipulated to concentrate fish downstream and into the net. The lack of undercut banks and deep pools enabled these methods to be used effectively on East Willow Creek.

A 50-foot by 6-foot bag seine with 1/4-inch nylon mesh was used to collect fish in Redd Cow Camp Reservoir.

3. Results

a. East Willow Creek

East Willow Creek is a small spring-fed stream and is a major tributary of Willow Creek, which flows into Piceance Creek. Field investigations of East Willow Creek were performed on July 17 and July 18, 1975. Results of these studies are discussed in the following subsections.

(1) Physical

East Willow Creek flows down a relatively narrow, flat-bottomed canyon in which the stream bed is deeply incised into the alluvial floor north of Section 33, T4S, R97W. The entrenched channel is 20 to 25 feet wide and 5 to 10 feet deep at the middle station and is approximately 20 feet deep at the lower station. The side walls of the channel appear relatively stable, and grasses and sedges are common along the stream. Pools are limited to slow-moving water areas near the banks; no large pools were found.

Near the southern boundary of the corridor, south of Section 28, T4S, R97W, the entrenched stream channel is shallow, usually less than 2 feet deep, and is approximately 2 feet wide at the upper station. Grasses and sedges are abundant along the narrow trench and in places nearly cover the stream. Flow in the narrow channel was swift, and no pool habitat was present.

Physical data recorded from each transect are given in Table XIV-1. The substrate at all stations was composed largely of gravel with variable amounts of rubble, sand and silt.

Table XIV–1 STREAM DRAINAGE CHARACTERISTICS FOR EAST WILLOW CREEK, JULY, 1975.

	Average gradient	Stream width (inches)	Stream depth (inches)	Substrate composition	Vegetative bank cover	Bank stability
Upper station						
Transect 1		22	7	Rubble and gravel with compacted silt	Poa pratensis and Scirpus sp.	Stable
Transect 2	3.0%	24	6	Gravel and sand with some rubble	Scirpus sp.	Stable
Transect 3	____	19	5	Gravel and sand	Scirpus sp.	Stable
Average		21.7	6.0			
Middle station						
Transect 1		48	4	Gravel and sand with some silt and rubble	Poa pratensis Eleocharis sp.	Stable
Transect 2	2.8%	48	5	Gravel and sand with some silt and rubble	Poa pratensis Eleocharis sp.	Stable
Transect 3	____	48	6	Gravel and sand with some silt and rubble	Poa Pratensis Trifolium sp.	Stable
Average		47.0	5.0			

Table XIV–1 (Continued)

	Average gradient	Stream width (inches)	Stream depth (inches)	Substrate composition	Vegetative bank cover	Bank stability
Lower station						
Transect 1		54	7	Sand and silt	Glyceria grandis Scirpus sp.	Stable
Transect 2	2.3%	46	7	Gravel and sand with some silt and rubble	Poa pratensis Scirpus sp.	Stable
Transect 3		42	7	Gravel and sand with some silt and rubble	Poa pratensis Scirpus sp.	Stable
Average		47.3	7.0			

(2) Periphyton

Periphytic growth in East Willow Creek was relatively inconspicuous and limited primarily to diatom (Bacillariophyceae) growth on substrate rocks. Of the 40 species of algae identified from the East Willow Creek samples, 36 were diatoms. Predominant diatom species were similar at all stations and consisted of Navicula cryptocephala and N. lanceolata.

Green algae (Chlorophyta) were found in abundance in limited areas attached to submerged sticks and vegetation. Both identified species are filamentous forms which produce large green mats. Because of their conspicuous nature, the relative abundances of these species are easily overestimated by a streamside viewer.

Blue-green algae (Cyanophyta) were represented by two species. Both species were uncommon at all three stations.

In general, East Willow Creek contained a fairly diverse assemblage of periphytic algae, which was dominated by a large number of diatom species. Diatoms are usually the most common group of algae in cool flowing-water environments such as East Willow Creek.

(3) Benthic Macroinvertebrates

Immature aquatic insects and aquatic worms were the predominant organisms collected from East Willow Creek. Mollusks (snails and clams) were present in abundance only at the lower station where they comprised nearly 30% of the total number of organisms collected.

Diptera (true flies) and Ephemeroptera (mayflies) were the predominant groups of aquatic insects collected. Two other common groups of stream insects, caddisflies (Trichoptera) and stoneflies (Plecoptera), were absent at the middle station but were present in low numbers at the upper and lower stations.

Samples collected at a given station varied in the total number of organisms they contained. The middle station was most variable with 312 organisms/ft^2 at transect number 2 and 22 organisms/ft^2 at transect number 1. This variability is probably related to substrate composition. The substrate at all stations was composed largely of gravel with variable amounts of rubble, sand and silt. In general, the larger the stones composing the substrate, the more diverse the invertebrate fauna, since large stones provide more available space for colonization. Sand and silt fill the interstices and crevices and reduce the habitat available for benthic macroinvertebrates. Thus, the collections which contained the most organisms usually contained more rubble and less sand and silt. In general, the abundance of macroinvertebrates in East Willow Creek was relatively low (mean of all samples was 105 organisms/ft^2), and probably

resulted from the large amounts of sand and silt present. Larger rubble, where not totally covered by fines, was usually firmly set into the stream bed by hard, compacted silt.

Diversity indices are an additional tool for measuring the quality of the environment and the effect of induced stress on the structure of a community of macroinvertebrates. Diversity indices calculated on the samples collected in East Willow Creek were, in general, relatively high and ranged from 2.28 to 3.38. This index is generally between 3 and 4 in unpolluted waters, and less than 1 in polluted water. Calculated equitabilities ranged from 68.5% to 94.8%, indicating that the total number of organisms collected was fairly evenly distributed among the species.

From previous investigations for the Tract, species composition, abundance and diversity in lower Willow Creek appear similar to that of upper Willow Creek. Substrate compositions which are similar in both locations partly explain these similarities.

(4) Fish

No fish were collected at any station on East Willow Creek. Stream morphology and flow of East Willow Creek are not favorable to fishery production.

Three species of fish--brook trout, mountain sucker and speckled dace--have been identified in lower Willow Creek during baseline investigations of the Tract area: However, all fish collected were taken near the confluence of Willow Creek and Piceance Creek and none has been collected at two stations located farther upstream.

b. Redd Cow Camp Reservoir

Redd Cow Camp Reservoir is a small, 3-acre to 4-acre spring-fed impoundment located in the valley of West Fork Stewart Gulch. Field investigations of this reservoir were performed on July 16 and July 17, 1975. The results of these studies are discussed below.

(1) Physical

The water of this reservoir was very clear, with a Secchi disc depth greater than 2 meters. *Chara* sp. and other submergent aquatic macrophytes cover the bottom and emergent macrophytes, *Scirpus acutus*, *S. americanus* and *Carex* spp., form a fringe around the reservoir. Substrate was composed largely of black, finely-divided organic matter, with a few areas of sand.

Maximum recorded depth of the reservoir was 2.5 meters near the outfall and mean depth was estimated at between 1.5 and 2 meters. Sediment deposition is not evident at either the junction where the spring feeding the reservoir, or the West Fork Stewart Gulch, enter the reservoir.

(2) Periphyton

True periphytic algae, (i.e., those growing attached to natural substrates), were rare in Redd Cow Camp Reservoir. Aquatic macrophytes and wood pilings were free of any evident periphytic growth. Rock substrates, which were rare, contained only a few species. These were limited in number. Predominant algae species collected were filamentous greens (Chlorophyta) and blue-greens (Cyanophyta), which form mats that become entangled among aquatic macrophytes or float on the water surface. The species collected lack means of attachment and, therefore, are not truly periphytic, but are frequently considered along with the periphyton. These floating greens and blue-greens, although relatively abundant, covered less than 1% of the reservoir's surface area, in contrast to many of the other spring-fed reservoirs in the area, which were 50% to 70% covered.

(3) Benthic macroinvertebrates

Tubificid worms and snails were the predominant organisms collected in Redd Cow Camp Reservoir. Three species of snails comprised greater than 50% of all organisms collected and totally dominated the upper station, where they comprised 88.5% of the animals collected. The majority of the snails were of the common genus Gyraulus.

Diversity and equitability were relatively low at the shallow inlet station because of the abundance of snails. Diversity at the deeper outlet station was low, but equitability was greater than at the shallow end because the greater numbers of animals were evenly divided between snails and worms. This low diversity is a natural situation for a pond with abundant submergent vegetation and muck bottom, and is not indicative of unnatural pollution.

(4) Fish

The blue-head mountain sucker (Catostomus discobolus) was the only species of fish collected from the reservoir. The 21 individuals collected ranged from 90 to 200 millimeters in total length and averaged 149 millimeters. The mean weight was 39.3 grams, and weight ranged from 8 to 86 grams. The larger individuals were apparently in reproductive condition as evidenced by the bright red stripes along their sides.

In addition to the adult suckers, numerous Catostomus sp. fry were collected. These were probably also blue-head mountain suckers, but adult characteristics were not yet developed.

No trout were collected in the present study; however, seining was limited to the more shallow areas (less than 5 feet) and angling was not employed. Fish, possibly trout, were noted feeding on the surface.

c. Scandard Gulch

Scandard Gulch is a tributary of Willow Creek, entering it about 2 miles upstream from the junction of Willow and Piceance Creeks. Field investigations of Scandard Gulch were performed on July 15, 1975.

Scandard Gulch, like the majority of the tributaries of Piceance Creek, has only ephemeral flow. The valley floor of Scandard Gulch is flat and the predominant vegetation is sagebrush, some rabbitbrush and grasses. The stream channel is not well defined in the valley between Section 15, T4S, R97W and the middle of Section 25, T3S, R97W. A few small discontinuous gullies occur in this region, but these are usually wide (15 to 20 feet) and shallow (usually less than 2 feet) and are totally covered with vegetation. From the center of Section 25, T3S, R97W to the confluence with Willow Creek, the stream channel is incised deeply into the alluvial floor. Gully depth varies from approximately 5 to 10 feet, and width at the bottom of the gully averaged 5 feet at the lower sampling station. No vegetation was growing in the bottom of the trench and the substrate was largely sand and some gravel. Gullies have been formed where the valley slope and the valley alluvium are steepest. The stream drainage characteristics for Scandard Gulch are summarized in Table XIV-2.

Small earthen dams have been built on the upper regions of Scandard Gulch. In the northwest corner of Section 11, T4S, R97W there was a series of three small dams. The upstream dam impounded a small pond with approximately a 100-square-foot surface area and a depth of about 2 inches. The basin contained about 3 feet of silt. The pond of the middle dam (approximately 300 square feet in surface) contained about 6 inches of water and held 3 feet or more of silt deposit. The downstream dam was dry and contained much less silt. Apparently the water in the ponds was the result of locally heavy rains which occurred during the evening of July 14 and the morning of July 15, 1975. Water overflowed the first dam and began to fill the second, which was 5 to 6 feet high; it appeared that water had not flowed beyond this point. Two other small dams were noted in the middle of Section 2, T4S, R97W, located close to a windmill. These dams pond the overflow water from a watering tank at the windmill, and thus water is more permanent here than farther up-valley. These ponds contained high concentrations of phytoplankters and zooplankters, and were very rich in nutrients from cattle wastes deposited in and around them. No springs or other standing bodies of water were noted in Scandard Gulch.

d. West Fork Stewart Gulch

West Fork Stewart Gulch, like Scandard Gulch, is an ephemeral stream and was dry when visited on July 16, 1975. The valley of this gulch is wider than that of Scandard, and its lower region is used more extensively for agricultural production. Scattered sagebrush and rabbitbrush (with some grasses) dominate the vegetation in the upper regions

Table XIV–2 STREAM DRAINAGE CHARACTERISTICS FOR SCANDARD GULCH, JULY, 1975.

	Slope in Percent	Substrate Composition	Vegetation	Comments
Upper station	5.0	Sandy loam	Scattered sage, rabbitbrush, bluegrass, cheatgrass.	No defined streambed.
Middle station	2.5	Sandy loam	Scattered sage (which has been sprayed), cheatgrass, bluegrass, and rabbitbrush.	Wide poorly defined stream channel, channel vegetated.
Lower station	3.0	Predominately sand with some gravel.	Sage, cheatgrass.	Stream incised 8 to 10 feet deep and approximately 6 feet wide. No vegetation in gully.

of the valley, and sagebrush is again common in the lower 2 miles. Grasses comprise the major vegetative cover in the remainder of the valley. Alfalfa has been planted in the segment below Redd Cow Camp Reservoir. The stream drainage characteristics for West Fork Stewart Gulch are summarized in Table XIV-3.

West Fork Stewart Gulch is deeply gullied only in the region located on the Tract. No definable streambed was noted in the upper region, which is approximately 5 miles from Section 34, T4S, R97W to Section 1, T4S, 97W. Within this region several natural dams have been formed where tributaries have deposited alluvial fans which extend completely across the valley floor. Thus, water flowing down the valley tends to be stopped by these fans, unless flow is sufficient to trench through them. From Section 1, T4S, R97W to Redd Cow Camp Reservoir, the stream channel is characterized by a series of small discontinuous gullies, ranging in size from less than 1 foot to a maximum of 5 feet deep. These gullies are not actively eroding and vegetation has stabilized the channel. Three springs emerge in this region, the largest feeding Redd Cow Camp Reservoir. The other springs are located in the middle of Section 31, T3S, R96W. A dam has been placed below these springs; however, the volume of water from them is insufficient to maintain a reservoir and only a wet meadow exists here.

The stream bed below Redd Cow Camp Reservoir has been dredged to form a ditch which parallels the road. This ditch is 2 to 4 feet wide, 1 to 2 feet deep and is apparently used to irrigate the alfalfa with water from the reservoir. Vegetation, predominantly cheatgrass, is growing in the ditch.

B. Hydrology

1. Introduction

Hydrological investigations were conducted concurrently with aquatic biological studies to collect baseline data on water quality and stream morphology. Water-quality data were collected at the upper and lower stations on East Willow Creek and at Redd Cow Camp Reservoir (Figure XIV-2). Field investigations were performed between July 17 and 19, 1975.

2. Methods

a. Water Quality

Grab samples of water for chemical analysis were collected and transported to a commercial laboratory in acid-washed, liter Nalgene containers. Water samples were analyzed for calcium, magnesium, sodium, potassium, sulfate, chloride, turbidity and total dissolved solids (TDS). Temperature, pH and dissolved oxygen were measured in the field. Dissolved oxygen was measured with a YSI model 54 RC dissolved oxygen meter. Alkalinities were determined by titration, according to standard methods (APHA, 1971). Hydrogen ion activity (pH) was measured with a Corning portable pH meter.

Table XIV–3 STREAM DRAINAGE CHARACTERISTICS FOR WEST FORK STEWART GULCH, JULY, 1975.

	Slope in Percent	Substrate Composition	Vegetation	Comments
Upper station	3.0	Mostly fine sand with some silt, moderate humus.	Rabbitbrush, scattered sage, western wheatgrass, cheatgrass, basin wildrye.	No definable streambed, sampling station located 100 yds. downstream from windmill.
Middle station	2.5	Mostly silt with some sand, much humus.	Predominately western wheatgrass, basin wildrye, and cheatgrass.	Streambed poorly defined, appears to be 6 inches deep and less than 2 feet wide and totally vegetated.
Lower station	2.4	Mostly silt, some organic matter.	Predominately alfalfa with some smooth brome and other grasses.	Stream was confined to drainage ditch, station located upstream from vegetation enclosure.

b. Peak Runoff

The Soil Conservation Service emergency-spillway hydrograph analysis method was used to calculate probable peak flows for Scandard Gulch, West Fork Stewart Gulch and East Willow Creek. This method produces a synthetic hydrograph which reflects the watershed parameters and storm characteristics that are determined for a given drainage basin. This approach allows calculation of flood events for small drainage basins where long-term runoff records are not available.

Calculation of peak discharges in this study was based on the 1% probability (100-year recurrence) of a 6-hour storm producing 1.9 inches of rainfall.

3. Results

a. Water Quality

Results of the water-quality analyses from Redd Cow Camp Reservoir and the upper and lower Willow Creek stations are given in Table XIV-4.

The waters of East Willow Creek were relatively alkaline. Sodium and calcium were the predominant positive ions, while bicarbonate and sulfate were the major negative ions. No large differences in chemical composition were observed between stations on the creek. Calcium and potassium concentrations were slightly lower at the lower station; the other major ions were higher at the upper station. Water at the upper stations was more turbid than water at the lower station, probably because of a rainy runoff just prior to sampling.

The USGS maintains a continuous-flow water-quality station located on lower Willow Creek. This station commenced operation in April 1974 and has collected data on many physical and chemical parameters. In general, the major chemical constituents found at this station are present in concentrations that are two to three times greater than those recorded at East Willow Creek. It is not known whether the increase in concentrations is gradual over the approximate seven miles between the present sampling sites and the USGS station, or whether the increase occurs more suddenly because of localized inflow of ground water that is high in dissolved salt content. However, the concentrations of the major constituents in both creeks are well within the tolerance range of most organisms. The USGS has also collected data on trace elements and pesticide concentrations in Willow Creek. Trace elements were all present in low concentrations; none of the 10 common pesticides was detected.

The water of Redd Cow Camp Reservoir was slightly less alkaline than that of East Willow and Willow Creeks. However, concentrations of dissolved solids, calcium, magnesium, sodium and sulfate were considerably greater in the reservoir than in the creeks. The water of this reservoir was very transparent, with a turbidity of 2 Jackson turbidity units.

Table XIV–4 WATER QUALITY ANALYSES –
REDD COW CAMP RESERVOIR AND EAST WILLOW CREEK, JULY, 1975

	Location:	Redd Cow Camp Reservoir	Upper station East Willow Crk	Lower station East Willow Crk
	Date sampled:	July 16, 1975	July 17, 1975	July 18, 1975
Parameter	Units			
Calcium	mg/l	305	58	51
Magnesium	mg/l	81	24	39
Sodium	mg/l	160	64	78
Potassium	mg/l	0.2	1.5	0.6
Chloride	mg/l	2.1	6.4	7.6
Sulfate	mg/l	405	101	173
Total Alkalinity	mg/l as $CaCO_3$	285	325	340
Phenolphthalein Alkalinity	mg/l as $CaCO_3$	40.5	0	22.5
Total Dissolved Solids	mg/l	900	544	634
Turbidity	JTU	2	295	12
pH	units	8.7	7.9	8.6
Temperature	°C	20	14	18.8
Dissolved Oxygen	ppm	10.4	8.2	7.8
Dissolved Oxygen saturation	%	113	79	83

The water had a relatively high dissolved oxygen concentration, and concentrations did not significantly decrease with depth.

The USGS has also recently established water-quality and flow stations on Scandard, West Fork Stewart and Sorghum Gulches. Flow has been recorded only twice in Scandard Gulch since the station was started on April 19, 1974: one day in January 1975, and two consecutive days in March 1975. Maximum recorded flow occurred in January, 0.36 CFS.

West Fork Stewart Gulch has two stream gauging stations, one located near its confluence with Piceance Creek, and the other upstream at the south boundary of the Tract. The upper station records the flow and water quality of a small spring; flow at the lower station results from runoff. Flow at the lower station has occurred only once since the station was established on April 17, 1974. This flow was recorded from March 2 to March 6, 1975, with a maximum recorded flow of 1.6 CFS.

Sorghum Gulch also has two USGS gauging stations; one is located at the junction with Piceance Creek and the other is upstream near the south boundary of the Tract. The lower station has not recorded flow since these stations were installed in April 1974. The upper station recorded flow only on five days in March 1975, with a maximum flow of 0.05 CFS.

b. Peak runoff

Estimated peak discharges for the 100-year flood for Scandard Gulch, West Fork Stewart Gulch and East Willow Creek, along with physical watershed characteristics of these drainages, are given in Table XIV-5.

Peak runoff amounts are strongly influenced by the antecedent moisture conditions of the watershed. The SCS hydrograph analysis method recognizes three classes of antecedent moisture conditions (AMC) for estimating runoff, of which AMC-III (soil nearly saturated) was used to calculate the results in Table XIV-5. Use of AMC-III values should result in maximum expected flood estimates. Thus, the peak discharge estimates shown are "worst case" situations.

C. Avifauna

1. Introduction

The objectives of the avifauna investigations were to identify those bird species that occur within, and immediately adjacent to, the proposed Multi-purpose Spur Corridor, and to determine the relative densities and usage of dominant habitats. Because potential impacts of corridor development and operation on birds should be concentrated during the period of right-of-way clearing and ground disturbance, and because these activities are anticipated to occur during summer months, field work and interpretation have focused on the breeding bird communities of principal corridor habitats. Where appropriate, data obtained on winter resident and migrant species in comparable habitats on the Tract have been utilized to enhance interpretation.

Table XIV–5 PEAK DISCHARGE ESTIMATES – SCANDARD GULCH, WEST FORK STEWART GULCH AND WILLOW CREEK

Parameter	Units	Scandard Gulch	West Fork Stewart Gulch	East Willow Creek
Drainage Area	Sq. mi.	7.8	15.6	14.8
Greatest length of travel for surface runoff	ft.	46,500	66,000	40,100
Average width of watershed	ft.	5,000	7,600	11,700
Altitude at top of watershed	ft.	8,080	8,500	8,400
Altitude at mouth of watershed	ft.	6,420	6,440	6,920
Altitude change	ft.	1,660	2,060	1,480
Average watershed slope	%	3.6	3.1	3.7
Peak discharge	c.f.s	1,032	1,548	467
Watershed flood yield	cfs/sq. mi.	132	99	32

2. Methods

On July 16 and July 30, 1975, reconnaissance of the proposed Tract service corridor preceded selection of avian census transects. The purpose of the initial inspections was to assure that transects became established in each of the principal habitat types which will be traversed by the proposed corridor, and to determine if any unusual habitats of sufficient size to attract special avian assemblages were present within the corridor.

The five major habitat types censused were bottomland sagebrush, pinyon-juniper, woodland, mixed mountain shrub land, aspen and upland transition. One transect was located, marked and plotted on a map within a representative area of each of the first four types. Because the upland transition vegetation type appeared to be the dominant habitat within the proposed corridor vicinity, two transects were established in this type. Thus, six transect locations were selected, each approximately 2600 feet in length. Locations of transects are depicted on Figure XIV-2. Birds utilizing the six transect areas were censused between July 31 and August 3, 1975. Each transect was checked twice, once during early morning hours and once during the early evening period.

The Emlen strip census procedure was used to collect data from which quantitative estimates of avian densities could be calculated. The field technique consisted of an observer walking slowly along the transect and recording all individual birds seen or heard, by species, and their perpendicular distance from the transect route. Perpendicular distance categories of 0 to 10 feet, 10 to 25 feet, 25 to 50 feet, 50 to 100 feet, 100 to 200 feet and 200 to 400 feet on either side of the route, were used. A hand-held range finder was used to verify perpendicular distances. These distances were later used to calculate a coefficient of detectability (CD) for each species; the CD represents an adjustment factor which improves accuracy of density estimates.

Population densities were determined by three calculation methods. Method A simply expresses the total number of individuals of a species recorded in the census in terms of total area sampled. Method B adjusts this estimate using the CD, which recognizes that species differ in their conspicuousness to the observer, and thus have differing probabilities of being recorded as distance increases from the transect route. The coefficient represents the proportion of a species' population of an area which is ordinarily detected by an observer traversing the transect. Method C further adjusts this estimate to account for underestimation of densities close to the transect route, where calculation B assumes complete counts.

The validity of any of these estimates varies for different species. Thus, professional judgment stemming from experience with the species and habitats was used in selecting the best method to determine density estimates for each species. For species which are either associated with distinctive habitat types or are quite conspicuous and occupy large

activity areas, method A usually provides the best estimation. For most other species, method B yields the best approximation of actual densities, particularly for secretive or quiet species that characteristically remain undetected until flushed at close range (e.g., nonsinging song sparrows, Virginia's warblers).

While the Emlen census provided data on the species utilizing the surveyed areas during late summer, they did not identify the full range of species expected throughout the entire area of investigation and during other seasons. Field data collected in comparable habitats during bimonthly avian investigations on the Tract were used to supplement data obtained in corridor studies; this aided understanding of bird species utilization of the study area. A species list of birds observed in the corridor or in comparable habitats on the Tract is included in the results section.

All sagegrouse activity observed on the corridor was noted. When sage grouse were encountered, they were flushed and tallied according to sex and age. Data were reported on a young/adult basis and related to literature values of production counts. Habitat affinities and habitat characteristics of strutting grouse (leks) were also obtained from literature accounts. All sagebrush habitats within the preferred Multi-purpose Spur Corridor were examined, and habitats offering potential as spring lek grounds were mapped.

Raptorial birds include the vultures, hawks, eagles, falcons and owls. Also included in this category, because of similar ecological role, is the common raven. Raptors noted during all avifauna field activities were recorded as to location of observation, species and age class. Age designation was based on standard, widely accepted criteria. While the field investigations were conducted, all raptor nests encountered were examined for activity status and their locations were plotted on field maps. The nests were not directly examined but observed from a distance with a spotting scope. Information on raptors and raptor nests within the corridor vicinity obtained during routine investigations on the Tract was used to aid in the determination of anticipated status of raptor species. Areas of potential raptor nesting habitat were mapped.

An owl survey traversing the route followed by the Multi-purpose Spur Corridor was conducted during two nights. Both surveys commenced at dark. At every 0.8 km., a stop was made and the observer recorded the species and number of all owls and goatsuckers seen or heard during a 5-minute period.

Nomenclature used in this report follows the American Ornithologists' Union <u>Checklist of North American Birds</u> (AOU, 1957) as updated by the 32nd supplement to the checklist (AOU, 1973).

3. Strip Census Results

a. Songbirds

(1) Pinyon-Juniper Woodland (Transect 1)

This mature, but sparselyvegetated stand of mixed pinyon pine and juniper, supported a high diversity but low density of birds (Table XIV-6). The black-throated gray warbler comprised 52% of the total relative abundance of the breeding avian community within this type. A flock of common bushtits, a species which flocks and forages in large numbers in shrub habitats and open woodlands was observed, but this species only accounted for 8% of the relative density. Of the 12 species observed on this route, only the mountain chickadee and the common raven are known to winter in the pinyon-juniper habitat. According to the Second Quarterly Report, Inventory of Avifauna at Tract C-b Shale Oil Project (ECI 1975), other species that typically utilize pinyon-juniper habitat during winter are the Townsend's solitaire, pinyon jay, mountain chickadee, red-breasted nuthatch, white-breasted nuthatch and plain titmouse. The robin, mountain bluebird, yellow-rumped warbler, black-capped chickadee, pine siskin and gray-headed junco were species observed during fall.

(2) Bottomland Sagebrush (Transect 2)

The seven species found occupying bottomland sagebrush habitat within the census transect were those expected to nest within such communities in this portion of Colorado (Table XIV-6). The house wren was the most abundant species encountered. Violet-green swallows, although not observed during quantitative censuses, have been seen in large numbers feeding on insects above this bottomland sagebrush community. Six of the seven species observed on this transect are migratory and will not occur in the area during winter. Of these, only the scrub jay winters in this habitat. According to Tract investigations, other species expected to winter in the bottomland sagebrush type include the tree sparrow, song sparrow, robin and northern shrike.

(3) Aspen (Transect 3)

Of the eight species recorded in this dense stand of aspen, the house wren, a species utilizing many types of habitats in the corridor vicinity, accounted for 51% of the total relative density, while the yellow-rumped warbler and western flycatcher together accounted for an additional 38% (Table XIV-7). None of these species has been observed wintering in aspen within this general region. The gray-headed junco, mountain chickadee and black-capped chickadee have been observed in the aspen type during Tract investigations more than any other species in the fall and winter. These three species are generally considered to be associated with large aspen stands.

Table XIV–6 AVIAN SPECIES DENSITIES – CORRIDOR TRANSECTS 1 AND 2, JULY 30-31, AND AUGUST 2, 1975

TRANSECT 1

Species	Method of Estimation*	Number Observed	Density**	% Rel. Density***
Broad-tailed Hummingbird	B	1	41	3.2
Common Flicker	A	2	10	0.8
Common Raven	A	1	5	0.4
Mountain Chickadee	B	2	21	3.2
Common Bushtit	A	20	103	8.1
Blue-gray Gnatcatcher	B	6	103	8.1
Black-throated Gray Warbler	B	8	662	52.0
Rufous-sided Towhee	B	8	41	3.2
Green-tailed Towhee	B	2	10	0.8
Brewer's Sparrow	B	7	72	5.7
Chipping Sparrow	B	11	185	14.5
	Total	68	1273	100.0

TRANSECT 2

Species	Method of Estimation*	Number Observed	Density**	% Rel. Density***
Hummingbird sp.	B	2	21	0.9
Scrub Jay	A	2	10	0.4
House Wren	B	15	1637	71.4
Blue-gray Gnatcatcher	B	6	123	5.4
Green-tailed Towhee	B	5	103	4.5
Vesper Sparrow	B	7	72	3.1
Brewer's Sparrow	B	13	328	14.3
	Total	50	2294	100.0

* See Methods section.

** Density in birds/km^2 of appropriate habitat.

*** Percentage Relative Density was calculated as:

$$\%\ \text{Relative Density Total} = \frac{\text{Density of Species}}{\text{Density of all species}} \times 100$$

Table XIV–7 AVIAN SPECIES DENSITIES – CORRIDOR TRANSECTS 3 AND 4, AUGUST 2 AND AUGUST 3, 1975

	TRANSECT 3					TRANSECT 4			
Species	Method of Estimation*	Number Observed	Density**	% Rel. Density***	Species	Method of Estimation*	Number Observed	Density**	% Rel. Density***
Common Flicker	A	3	15	0.7	Sage Grouse	A	2	10	0.4
Hairy Woodpecker	A	2	10	0.5	Mourning Dove	B	1	82	3.1
Western Flycatcher	B	4	331	16.3	Broad-tailed Hummingbird	B	3	410	15.3
Clark's Nutcracker	A	2	10	0.5	Empidonax Flycatcher	B	6	410	15.3
House Wren	B	5	1026	50.6	Black-capped Chickadee	B	2	10	0.4
Hermit Thrush	B	4	164	8.2	House Wren	B	1	10	0.4
Blue-gray Gnatcatcher	B	1	21	1.0	Robin	A	1	5	0.2
Yellow-rumped Warbler	B	11	451	22.2	Orange-crowned Warbler	B	3	164	6.1
					Green-tailed Towhee	B	20	981	36.6
					Song Sparrow	B	2	21	0.8
					Brewer's Sparrow	B	6	165	6.1
					Vesper Sparrow	B	29	411	15.3
	Total	32	2028	100.0		Total	76	2679	100.0

* See Methods section.

** Density in birds/km^2 of appropriate habitat.

*** Percentage Relative Density was calculated as:

$$\text{\% Relative Density Total} = \frac{\text{Density of Species}}{\text{Density of all species}} \times 100$$

(4) Mixed Mountain Shrubland (Transect 4)

The green-tailed towhee, vesper sparrow, broad-tailed hummingbird and an Empidonax flycatcher species dominated this mixed stand of Gambel's oak, serviceberry, mountain mahogany, bitterbrush and snowberry by cumulatively contributing more than 82% of the total avian density (Table XIV-7). Mixed flocks of black-capped chickadees, mountain chickadees and ruby-crowned kinglets dominate the mountain-shrub community in fall, and mountain chickadees, dark-eyed and gray-headed juncos were observed in this habitat during winter.

(5) Upland Transition (transects 5 and 6)

The vegetation type of both the transects that traverse upland transition habitats consists of a scattered overstory of immature pinyon and immature juniper with a dense understory of sage and serviceberry. Seventeen bird species were recorded in this habitat type (Table XIV-8). Virginia's warbler, orange-crowned warbler and Brewer's sparrow accounted for 72% of the total avian density in Transect 5 and the house wren (44%) and Brewer's sparrow (29%) were the most abundant in Transect 6. Transect 6 supported a slightly denser overstory of trees; and the American kestrel, scrub jay, mountain bluebird and black-throated gray warbler were found utilizing the trees for foraging, perching or cover. These species were not observed in the area of Transect 5. This transect, although not having as great an avian density as Transect 6, supported a greater variety of brushland species (Virginia's warbler, orange-crowned warbler, song sparrow and vesper sparrow). Six species were common to both transects; and the American robin, common flicker, American kestrel, song sparrow and black-billed magpie are all known to winter on the Tract.

b. Upland Gamebirds

(1) Sage Grouse

Sage-grouse density in the region is light and this grouse has been observed in only scant numbers in the area southeast of the Tract. However, during the 5-day study period between July 30 and August 3, 1975, 13 sage grouse (6 juveniles and 7 adults) were observed in the immediate vicinity of the proposed Multi-purpose Spur Corridor. All observations occurred along a 3-mile segment of the corridor vegetated by sagebrush and mixed shrub. This indicates a localized, but relatively dense population of sage grouse within the corridor vicinity. The sightings of juveniles provides clear evidence that sage grouse are nesting in the sagebrush habitat traversed by the proposed corridor. According to previous studies, approximately 80% of all sage-grouse nests are found in association with the sagebrush vegetation type. Thus, because of these observations, all stands of upland sagebrush within the corridor area have been designated as possible nesting sites.

Table XIV–8 AVIAN SPECIES DENSITIES – CORRIDOR, TRANSECTS 5 AND 6, AUGUST 1 AND AUGUST 2, 1975

TRANSECT 5

Species	Method of Estimation*	Number Observed	Density**	% Rel. Density***
Broad-tailed Hummingbird	B	1	83	2.4
House Wren	B	7	287	8.1
Robin	A	2	10	0.3
Blue-gray Gnatcatcher	B	4	110	3.1
Orange-crowned Warbler	B	8	576	16.3
Virginia's Warbler	B	19	1233	35.0
Rufous-sided Towhee	B	1	5	0.1
Green-tailed Towhee	B	23	185	5.3
Song Sparrow	B	1	41	1.2
Brewer's Sparrow	B	16	746	21.2
Vesper Sparrow	B	3	246	7.0
	Total	85	3522	100.0

TRANSECT 6

Species	Method of Estimation*	Number Observed	Density**	% Rel. Density***
American Kestrel	A	1	5	0.2
Black-chinned Hummingbird	B	1	205	8.4
Common Flicker	A	1	5	0.2
Black-billed Magpie	A	1	5	0.2
Scrub Jay	A	12	62	2.5
Robin	A	1	5	0.2
Mountain Bluebird	A	2	10	0.4
House Wren	B	14	1072	43.8
Blue-gray Gnatcatcher	B	3	62	2.5
Black-throated Gray Warbler	B	2	82	3.4
Rufous-sided Towhee	B	3	164	6.7
Green-tailed Towhee	B	13	67	2.7
Brewer's Sparrow	B	22	705	28.8
	Total	76	2449	100.0

* See Methods section.

** Density in birds/km^2 of appropriate habitat.

*** Percentage Relative Density was calculated as:

$$\%\text{ Relative Density Total} = \frac{\text{Density of Species}}{\text{Density of all species}} \times 100$$

(2) Mourning Doves

During the Tract corridor study, one mourning dove was observed on Transect 4, and many sightings were made during other field activities. The habitat in the lower valleys of the proposed corridor should support many nesting pairs during the breeding season, but because of the species' migratory status, the doves are not found wintering on the corridor.

c. Raptorial Birds

The occurrence of seven raptor species and two raptor nests was documented in the Multi-purpose Spur Corridor study during late July and early August, 1975. Turkey vulture, red-tailed hawk, Cooper's hawk, marsh hawk, American kestrel and common raven represented the diurnal raptors encountered. The long-eared owl was recorded during night transect work. Table XIV-9 lists the number of individual raptors encountered.

The two raptor nests were located in West Fork Stewart Gulch (Figure XIV-2). Both nests showed evidence of occupancy during the 1975 breeding season, and were constructed of a loose aggregation of twigs. The occupants of one nest are unknown, but it is assumed the nest was used by common ravens, great-horned owls or red-tailed hawks. The second nest site was used by a pair of red-tailed hawks.

Red-tailed hawks were sighted twice, once soaring over the pinyon-juniper woodland along West Fork Stewart Gulch, and once soaring over Scandard Gulch. They have been recorded as abundant during the breeding season throughout the Tract, and are known to winter within the corridor study area.

Two turkey vultures were observed soaring over Transect 5 and one was encountered perched on a dead snag on the west slope of Scandard Gulch. The turkey vulture utilizes many habitat types and hunts over a wide area. Its presence on the Multi-purpose Spur Corridor and over the Tract during the breeding season indicates that it is probably nesting in the general region. Turkey vultures are migratory and no individuals have been observed on the Tract study area during the winter.

The only Cooper's hawk recorded during field investigations of the corridor was observed flying low over West Fork Stewart Gulch. Other sightings of Cooper's hawks have been recorded within the Tract proper. Although no nests have been found within the corridor study area, sightings of the hawk within the corridor and adjacent areas during the breeding season indicate that it is probably nesting in the study area. It is principally a woodland species, and probably nests in the pinyon-juniper or mountain shrub habitats within the proposed corridor. It is not a winter resident.

An adult marsh hawk was observed hunting low over Transect 4. Previous field activities conducted on the Tract in 1974 indicate this species is a common raptor in the area. The marsh hawk is a bird of

Table XIV–9 RAPTOR SPECIES ENCOUNTERED
ALONG THE PROPOSED CORRIDOR***

Species	Total Number Observed	% Relative Abundance*
Turkey vulture	3	15.8
Red-tailed hawk	2	10.5
Cooper's hawk	1	5.3
Marsh hawk	1	5.3
American kestrel	7	36.8
Common raven	4	21.0
Long-eared owl	1**	5.3
TOTAL	19	100.0

* Percentage Relative Abundance was calculated as:

$$\%\ \text{Relative Abundance} = \frac{\text{number individuals of a species}}{\text{Total individuals of all species}} \times 100$$

** Observed during night transects on July 30 and 31, 1975.

*** Total encounters during Emlen transects night censuses, and opportunistic sightings.

open fields and marshes, and avoids heavily forested areas. No nests have been recorded, but suitable nesting habitat for this hawk does occur within the Multi-purpose Spur Corridor. The pastures in West Fork Stewart Gulch and the sparsely-vegetated mountain shrub stands located on both slopes adjacent to the proposed right-of-way are probably nesting areas. It has been recorded as a wintering species for the area.

American kestrels, the most abundant raptor encountered, were observed throughout the corridor study area. It is probable that this falcon nests in the vicinity. Unlike most falcons, the kestrel will nest in deserted woodpecker holes and hollow trees as well as on cliff faces. The small cliff faces along sections of West Fork Stewart Gulch and Scandard Gulch, and the stands of pinyon-juniper woodland within the corridor study area, could support a substantial nesting population of kestrels. Kestrels have been observed on the Tract proper during the winter, but in low numbers.

The common raven is an abundant species throughout the Tract habitats. It was observed on four occasions during the corridor study, once on Transect 1, twice soaring over Scandard Gulch, and once perched on a dead snag in West Fork Stewart Gulch. Raven nests have been located on the Tract, and undoubtedly ravens are nesting within the proposed corridor. Their preferred nesting site is a crevice in a cliff face; some cliff faces along Scandard Gulch and West Fork Stewart Gulch provide suitable nesting habitat. The paucity of cliff faces and tall trees along the corridor probably limits the number of nesting ravens.

Rough-legged hawks are common wintering raptors in the Tract vicinity. This species has been observed within the proposed corridor area; the hawk appeared in the area by late November and remained through the winter.

Golden eagles have been recorded in the corridor and adjacent areas throughout the year. The golden eagle has often been observed at higher elevations south of the Tract during the summer. During winter, it commonly hunts over pinyon-juniper habitat and along rimrocks. An eagle nest is located on the Tract (ECI, 1975), but no eagle nests have been recorded within the Multi-purpose Spur Corridor study area. Neither sheer cliffs nor tall trees, the preferred nesting sites for golden eagles, are found along the proposed corridor; so the likelihood of finding nesting golden eagles along the preferred right-of-way is small.

The bald eagle is an uncommon winter resident of the Tract area. Three individuals were observed in the vicinity of the Tract corridor during March 1975. By April 1975, no bald eagles were observed in the vicinity of the Tract.

One owl species was recorded during the corridor field investigations; the long-eared owl was heard vocalizing in an aspen stand located at the southern end of the Multi-purpose Spur Corridor during the night owl transect. This owl species has been recorded on two other occasions within the Tract during the winter.

4. Species Listing

Tabulation of all species observed during field investigations conducted in October 1974, November 1974, January 1975, March 1975, July 1975, and August 1975, on the Multi-purpose Spur Corridor totals 78 species known to utilize habitats along the corridor and contiguous areas of comparable habitat type. These species are listed in Table XIV-10.

D. Wildlife

1. Introduction

The wildlife study is largely concerned with mammals, and to a lesser extent, reptiles and amphibians. The accompanying discussions of mammalian ecology draw from data gathered during August 1975 along the Multi-purpose Spur Corridor (Figure XIV-1) and from the baseline studies presently being conducted on the Tract. Additional information is presented from other reports that deal with the region through which the several alternate corridor routes pass.

A strong effort has been made to place this study within the appropriate environmental context, including not only the Tract, but the surrounding region as well. This broader perspective is desirable in view of the need to consider the dynamics of animal ecology.

2. Multi-purpose Spur Corridor

a. Mammalian Species

The Multi-purpose Spur Corridor route leads south from the Tract to the Piceance Creek/Parachute Creek divide (Figure XIV-1). Because of its proximity to the Tract, some previous investigations have been performed as part of the Tract baseline program. In particular, studies concerning deer migratory movements and coyote abundance were conducted in the area through which the Multi-purpose Spur Corridor is routed. The background information and the data from the studies conducted on the Corridor during early August 1975 are the basis of the following discussion.

The most common mammals along the Multi-purpose Spur Corridor are the golden-mantled ground squirrel, least chipmunk, deer mouse, desert cottontail, mule deer and long-tailed vole. The chipmunks and ground squirrels are the most conspicuous mammals during the warm seasons, although mule deer are commonly seen at higher elevations along the corridor route. These common species, along with cattle, are among the most important mammalian herbivores in the area as well. Domestic sheep are not grazed in this locality, but cattle grazing occurs over the entire length of the corridor during summer.

The most numerous and ecologically significant mammalian predators along the Multi-purpose Spur Corridor are the coyote and weasel. The food base of most importance in sustaining these two species includes the long-tailed vole and mule deer, with voles important to both predators, and deer important to the coyote, mainly as winter carrion.

Table XIV–10 AVIAN SPECIES MULTI-PURPOSE SPUR CORRIDOR AND IN COMPARABLE HABITATS ON TRACT C-b STUDY AREA, 1974-75

Scientific Name	Common Name
Anas platyrhynchos	Mallard
Buteo jamaicensis	Red-tailed hawk
Buteo lagopus	Rough-legged hawk
Aquila chrysaetos	Golden eagle
Haliaeetus leucoeephalus	Bald eagle
Circus cyaneus	Marsh hawk
Cathartes aura	Turkey vulture
Falco sparverius	American kestrel
Accipiter gentilis	Goshawk
Accipter cooperii	Cooper's hawk
Centrocercus urophasianus	Sage grouse
Zenaida macroura	Mourning dove
Otus asio	Screech owl
Bubo virginianus	Great horned owl
Asio otus	Long-eared owl
Aegolius acadicus	Saw-whet owl
Phalaenoptilus nuttallii	Poor-will
Chordeiles minor	Common nighthawk
Aeronautes saxatalis	White-throated swift
Selasphorus platycercus	Broad-tailed hummingbird
Archilochus alexandri	Black-chinned hummingbird

Table XIV–10 (continued)

Scientific Name	Common Name
Colaptes auratus	Common flicker
Sphyropicus thyroideus	Williamson's sapsucker
Dendrocopos villosus	Hairy woodpecker
Myiarchus cinerascens	Ash-throated flycatcher
Sayornis saya	Say's phoebe
Empidonax difficilis	Western flycatcher
Empidonax wrightii	Gray flycatcher
Contopus sordidulus	Western wood pewee
Eremophila alpestris	Horned lark
Petrochelidon pyrrhonota	Cliff swallow
Hirundo rustica	Barn swallow
Tachycineta thalassina	Violet-green swallow
Aphelocoma coerulescens	Scrub jay
Gymnorhinus cyanocephalus	Pinyon jay
Pica pica	Black-billed magpie
Nucifraga columbiana	Clark's nutcracker
Corvus corax	Common raven
Parus gambeli	Mountain chickadee
Parus atricapillus	Black-capped chickadee
Parus inornatus	Plain titmouse
Psaltriparus minimus	Common bushtit
Sitta carolinensis	White-breasted nuthatch

Table XIV–10 (continued)

Scientific Name	Common Name
Sitta canadensis	Red-breasted nuthatch
Oreoscoptes montanus	Sage thrasher
Trogbdytes aedon	House wren
Salpinctes absoletus	Rock wren
Catherpes mexicanus	Canyon wren
Turdus migratorius	Robin
Myadestes townsendii	Townsend's solitaire
Hylocichla guttata	Hermit thrush
Sialia currvcoides	Mountain bluebird
Polioptila caerulea	Blue-gray gnatcatcher
Regulus calendula	Ruby-crowned kinglet
Lanius excubitor	Northern shrike
Vireo gilrus	Warbling vireo
Vireo solitarius	Solitary vireo
Vireo olivaceus	Red-eyed vireo
Vermivora celata	Orange-crowned warbler
Vermivora virginae	Virginia's warbler
Oporornis tolmiei	MacGillvray's warbler
Dendroica coronata	Yellow-rumped warbler
Dendroica nigrescens	Black-throated gray warbler
Sturnella neglecta	Western meadowlark
Molothrus ater	Brown-headed cowbird
Pheucticus melanocephalus	Black-headed grosbeak

Table XIV–10 (continued)

Scientific Name	Common Name
Carpodacus mexicanus	House finch
Spinus pinus	Pine siskin
Chlorura chlorura	Green-tailed towhee
Pipilo prythrophthalmus	Rufous-sided towhee
Pooecetes gramineus	Vesper sparrow
Junco caniceps	Gray-headed junco
Junco hyemalo	Dark-eyed junco
Spizella arborea	Tree sparrow
Spizella passerina	Chipping sparrow
Spizella breweri	Brewer's sparrow
Zonotrichia leucophrys	White-crowned sparrow
Melospiza melodia	Song sparrow

A quantitative sampling effort was performed during early August 1975 over the length of the Multi-purpose Spur Corridor in order to document the existing species of small mammals, their habitat affinities, and their general levels of abundance (Table XIV-11). A linear arrangement of live traps was used at seven locations along the corridor from 7200 to 8500 feet elevation. Twenty live traps were spaced at 15 meter intervals at each of the seven sites along transects through homogeneous vegetation. These sites were sampled by trapping during consecutive days to give an equal trapping effort at each site (100 trap-nights; 20 traps set for 5 nights).

Sixteen species of mammals were identified along the Multi-purpose Spur Corridor by trapping and by observations (Table XIV-12). Several additional species undoubtedly occur, with three species believed to have been encountered, although identifications were uncertain. These include the Colorado chipmunk, Uinta chipmunk and mountain cottontail. Studies regarding distributions of these species are continuing. The following additional species of mammals are very likely to be present along the corridor but were not identified: masked shrew, Apache pocket mouse, bushy-tailed woodrat, pinyon mouse, badger, bobcat, long-tailed weasel and striped skunk.

As mentioned, coyotes and weasels are the most important predatory mammals in the vicinity of the Multi-purpose Spur Corridor. Ermines (or short-tailed weasels) were trapped and sighted on several occasions and are apparently numerous.

Coyotes are abundant, especially in several upper valleys in the vicinity of the Multi-purpose Spur Corridor and near the Piceance Creek/Parachute Creek and Piceance Creek/Roan Creek divides. This judgment is based mainly on data obtained by using the U. S. Fish and Wildlife Service's standard coyote scent-post surveys during September 1974. An abundance index of 188 was obtained for a 15-mile survey line running adjacent to and crossing the corridor route. This index is high compared to other indices conducted throughout Colorado using identical methods. The mean value for Colorado during 1974 was 98, and indices were reported by the U. S. Fish and Wildlife Service ranging from 18 to 229.

The degree of predation by coyotes on deer has been studied for the Tract. These data help to estimate the magnitude of coyote-deer predation for this region. An age-class ratio of 133 fawns to 100 does (total of 182 animals observed) was obtained during November in 1974, in the agricultural meadows below the Tract. These data suggest that minimal fawn predation occurred the previous spring. A rather high fawn mortality occurred during the following winter, however, as evidenced by an estimate of 75 fawns to 100 does (198) obtained in May 1975. While coyotes are known to have contributed to some of this winter mortality, the proportion of total mortality caused by coyotes is unknown. Deer mortality studies being conducted on the Tract during this time were designed mainly to evaluate the importance of the various habitat types to over-winter deer survival, and not specifically to single out mortality causes. Nevertheless, two deer out of 20 winter carcasses examined

Table XIV–11 RELATIVE ABUNDANCE OF SMALL MAMMALS IN DIFFERENT HABITAT TYPES ALONG THE MULTI-PURPOSE SPUR CORRIDOR

Common name	Number captured along an altitudenal gradient						
	Pinyon-juniper woodland 7200 ft.	Upland sagebrush 7400 ft.	Mixed mountain shrub 7800 ft.	Mountain grass-land 8200 ft.	Aspen 8300 ft.	Aspen 8400 ft.	Mixed mountain shrub 8500 ft.
Wandering shrew	0	0	0	0	0	2	0
Red-backed vole	0	0	0	0	2	0	0
Least chipmunk	5	9	0	0	3	0	2
Sagebrush vole	0	2	0	0	0	0	0
Long-tailed vole	0	0	0	0	7	3	0
Deer mouse	37	31	17	12	1	0	10
Ermine	0	0	0	0	0	0	1
Index *	.37	.33	.17	.12	.10	.05	.11

* Index of relative abundance (Trapping Index) = total No. captures/No. trap-nights. Captures of least chipmunks have been omitted, since diurnal mammals do not yield valid comparative indices owing to the variation in time that traps are open during daylight hours.

Table XIV–12 MAMMALS IDENTIFIED ALONG THE MULTI-PURPOSE SPUR CORRIDOR

Scientific name, common name*	Habitat type(s) and elevation(s) of identified specimens	Apparent level of abundance**
Insectivora		
1. Sorex vagrans, wandering shrew	Aspen (8400 ft.)	Low
Lagomorpha		
2. Lepus townsendii, white-tailed jackrabbit	Mixed mt. shrub (8200-8500 ft.)	Low
3. Sylvilagus audubonii, desert cottontail	Chained rangeland; Upland sage; mixed mt. shrub (7000-8500 ft.)	Mod.
Rodentia		
4. Clethrionomys gapperi, Gapper's red-backed vole	Aspen (8300 ft.)	Mod.
5. Erethizon dorsatum, porcupine	Mixed mt. shrub (8500 ft.)	Low
6. Eutamias minimus, least chipmunk	Chained rangeland; pinyon-juniper woodland; upland sage; mixed mt. shrub (7000-8500 ft.)	High
7. Lagurus curtatus, sagebrush vole	Upland sage (7400 ft.)	Mod.
8. Microtus longicaudus, long-tailed vole	Aspen (8300-8400 ft.)	Mod.
9. Peromyscus maniculatus, deer mouse	Chained rangeland; pinyon-juniper woodland; upland sage; mixed mt. shrub (7000-8500 ft.)	High

Table XIV–12 (Continued)

Scientific name, common name*	Habitat type(s) and elevation(s) of identified specimens	Apparent level of abundance**
10. Spermophilus lateralis, golden-mantled ground squirrel	Chained rangeland; pinyon-juniper woodland; upland sage; mixed mt. shrub (7000-8500 ft.)	High
11. S. tridecemlineatus, thirteen-lined ground squirrel	Mixed mt. shrub; mt. grassland (8000-8500 ft.)	Low
12. Thomomys talpoides, northern pocket gopher	Mixed mt. shrub (8500 ft.)	Low
Carnivora		
13. Canis latrans, coyote	Chained rangeland; pinyon-juniper woodland; upland sage; mixed mt. shrub (7000-8500 ft.)	High
14. Mustela erminea, ermine	Mixed mt. shrub (8500 ft.)	Low
Artiodactyla		
15. Cervus canadensis, American elk	Mixed mt. shrub (8500 ft.)	Low
16. Odocoileus hemionus, mule deer	Upland sage; mixed mt. shrub; aspen (7500-8500 ft.)	High

* Nomenclature follows Armstrong (1972).

** Abundance ratings are relative to expected densities of conspecifics in near optimal habitats elsewhere in Colorado.

were killed by coyotes and more coyote kills undoubtedly occurred. Coyotes were fairly common at the lower elevations and near the lower extreme of the Multi-purpose Spur Corridor during winter, as judged by observations of tracks and deer-carrion feedings. During the August 1975 field trip, some tracks were observed along the dusty road traversing the corridor route; also coyotes were heard in the evenings.

One of the important prey species in the area is the long-tailed vole. They were captured only in the higher aspen groves during the August sampling period, but previously they have been found in the mixed mountain shrub communities at lower elevations. This latter habitat type is characteristic for the species. The montane vole constitutes a more important prey species in the lower, moist meadows, and together these two voles have accounted for the largest proportion of prey remains found in raptor casts (See Quarterly Data Reports). During August 1975, cottontail rabbit populations appeared low along the Multi-purpose Spur Corridor route, with more sightings and tracks observed in valleys near Piceance Creek. In some years, cottontails likely constitute a higher component of the total prey base required by the larger predators. Chipmunks and golden-mantled ground squirrels are likely to be less important in sustaining the larger predators since they hibernate during the more ecologically critical winter periods. Deer mice might be important, although this species tends to be poorly represented in predator food habitat studies. While each of these prey species have different habitat requirements, they are all rather widely distributed throughout the habitat types along the corridor, with none being restricted to special, limited habitat situations.

b. Big Game

Mule deer and elk are the only big game species that regularly can be found in the vicinity of the Multi-purpose Spur Corridor. Mule deer are very abundant, while elk are far less common. Three elk were observed on the corridor route during August, but otherwise there were no signs that indicated appreciable use of the immediate area.

(1) Mule Deer

The Multi-purpose Spur Corridor is approximately 11 miles long, rising from 6900 feet on the Tract to 8500 feet on the Piceance Creek/Parachute Creek divide (Figure XIV-1). Deer winter range occurs at the lower elevations, and summer range at the higher elevations; these ranges overlap in approximately the center of the corridor route (Figure XIV-3).

The gradient, shown in Figure XIV-3, which defines the approximate upper limit of winter range, was determined by aerial observations of tracks on snow during the previous winter (See Quarterly Data Reports), by direct field observations of deer throughout the year, and to some extent by deer pellet-group studies which will be described later. The lower limit of summer range was established mainly by observations of

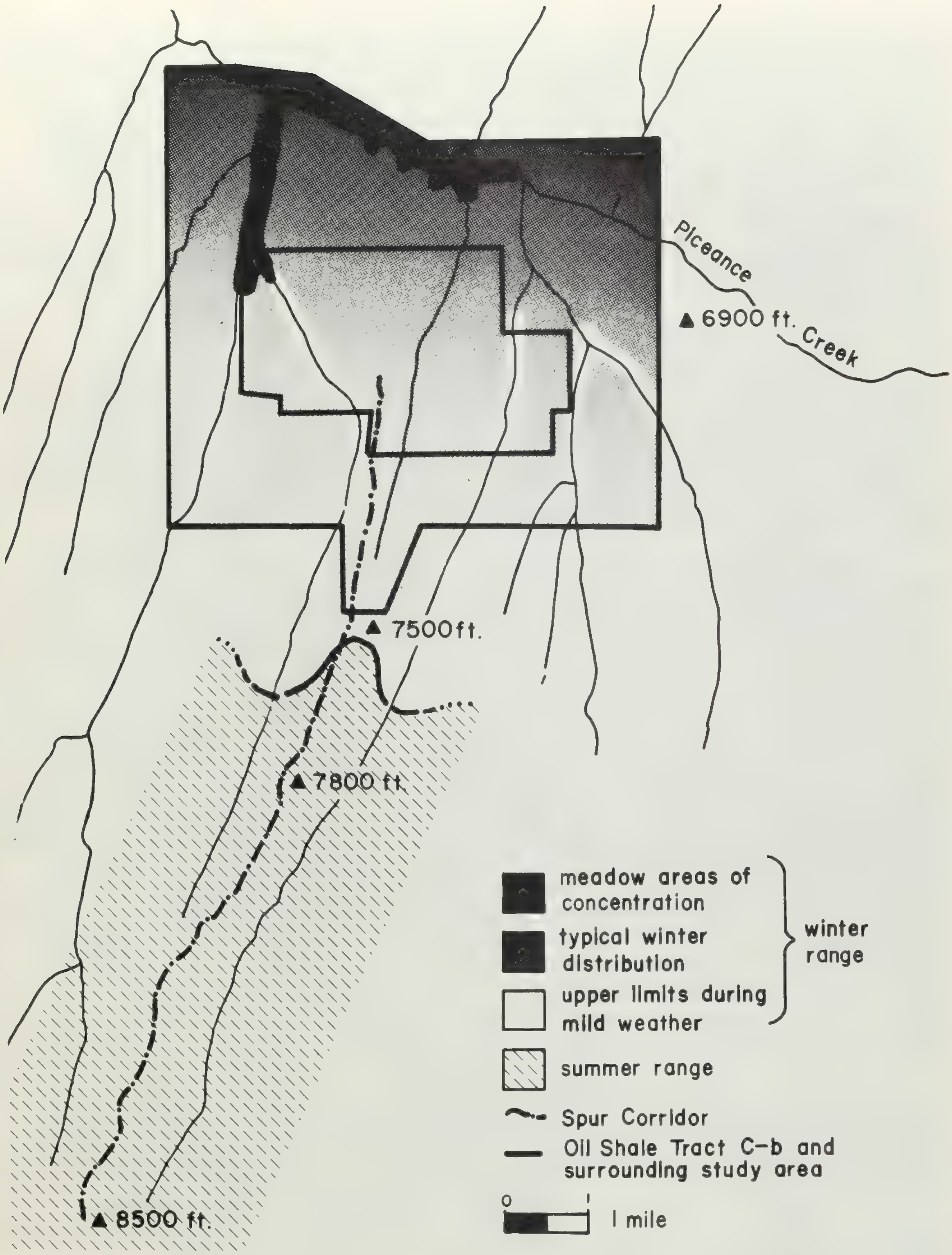


Figure XIV–3 MULE DEER RANGES
MULTI-PURPOSE SPUR CORRIDOR

deer tracks on the existing ranch road, which runs along the approximate corridor route. The conclusion from these combined investigations is that winter and summer deer ranges overlap between 7500 and 7800 feet along this ridge. While there is less information for the lower slopes and valleys adjacent to this ridge, it appears that winter range in these areas is at a considerably lower elevation, probably near 6500 feet. This estimate is based on winter observations of the typical upper limits of deer activities in valleys, though they are undoubtedly influenced by the generally deeper snow accumulations in the valleys as compared to the ridgetops.

(2) Deer Browse Studies

Since deer typically are widely dispersed throughout summer range, few direct observations are made and information regarding their whereabouts is sparse. Indirect observation of feeding activities, however, as manifested by the degree of browsing on key browse species, provides one means of evaluating local levels of deer abundance and relative differences in habitat utilization.

The key browse species along the Multi-purpose Spur Corridor are big sagebrush, mountain mahogany, bitterbrush and serviceberry. These four species were used in the browse evaluations. The main objectives of the browse study centered on adequately characterizing the present condition of the range in order that comparisons would be possible with studies conducted elsewhere in the region, and that documentation would be available for future studies of trends. The methods employed consisted of visually ranking the four key browse species in categories of light, moderate and heavy usage. The criteria used for ranking the degree of "hedging" caused by deer feeding is represented photographically on Figure XIV-4. Additionally, photographic documentation of all individual plants evaluated was obtained to overcome much of the inherent subjectivity of the more or less standard range survey methods. With reference to these photographs, it should be noted that the browse evaluation study was performed in August 1975, at the time of maximum summer growth. Consequently, the long leaders that are this year's growth constitute available forage for the coming year; the portion of the plant being evaluated for "browse condition" is the length of the older, woody stems at the base of these leaders.

Apart from photographically documenting the existing browse condition, the results of the range survey indicated heavy browse usage along the lower portion of the corridor (from 7000 to 7500 feet) and moderate usage at study sites above this point (from 7800 to 8400 feet). The range conditions would be characterized as poor and fair respectively, which is to say that deer usage, or deer population, over the past several years has been high in this local area.

A comparative evaluation of browsing intensity also was made on the ridges immediately to the east and west of the Multi-purpose Spur Corridor. These results indicated nearly the same degree of browsing intensity as along the corridor. When sampling sites on each ridge are

Figure XIV–4 DEER BROWSE USAGE CHARACTERISTICS

Appearance of the four major browse plants under different intensities of "hedging" by deer. The lengths of the older, woody stems at the base of the long leaders determine how plants are ranked for browse evaluation studies.

combined and one ridge is compared to another, the percentages of "heavily browsed plants" are: corridor, 53%; adjacent ridge to the west, 42%; adjacent ridge to the east, 55%. Thus, it seems that deer usage throughout the area adjacent to and including the proposed route of the corridor is approximately the same, and that the corridor route is not atypical.

(3) Deer Pellet-group Studies

The frequency of occurrence of pellet groups at various sites provides an additional means of evaluating both the relative usage by deer of different habitat types, and the relative number of deer along an altitudinal gradient. This latter concern assisted in evaluating the apparent overlap of winter and summer ranges.

The pellet-group study site locations along the Multi-purpose Spur Corridor were the same as those used for the browse studies. These locations are measured from the main meteorological tower on the Tract (located approximately one-half mile from the south boundary of the Tract): 0.5 miles (7000 ft.); 1.5 miles (7200 ft.); 3.5 miles (8400 ft). Methods used for pellet-group counts consisted of counting all distinct pellet groups within 40 randomly located circular quadrats (50 m^2 each) at each study site.

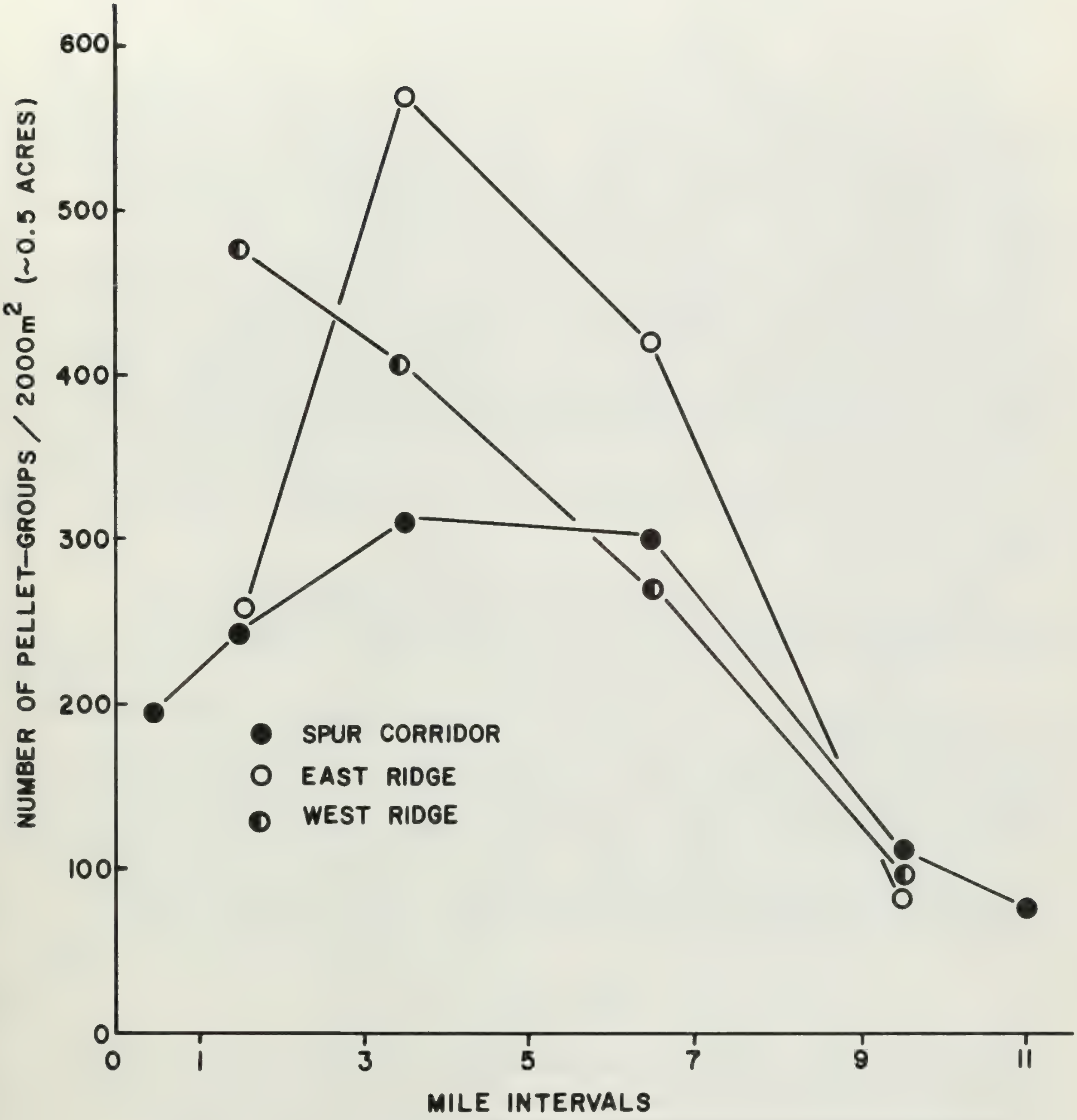
Estimates of the relative abundance of deer, as made from pellet-group counts, are generally consistent with the results of browse studies. The highest concentration of pellets and the heaviest browse utilization occurred in the pinyon-juniper woodland and the nearby upland sagebrush habitat types. Frequencies of pellet groups, unlike browse utilization, remained high up to 7800 feet in elevation (Figure XIV-5). These results, as well as winter and summer observations of tracks, provide the reasons for concluding that winter and summer deer ranges overlap between 7500 and 7800 feet. The lower browsing intensity in this overlap zone is probably a result of the dense browse available at this elevation.

Deer pellet-group counts are similar for the three adjacent ridges studied, with the exception of the sagebrush site on the east ridge opposite the 3.5-mile corridor location. The high density of pellets recorded for this site appear to result from the restricted and more clustered stands of a preferred browse type.

c. Reptiles and Amphibians

Collections of reptiles were made along the Multi-purpose Spur Corridor. Three species were identified: the wandering garter snake (highest elevation collected, 8500 feet); the northern sagebrush lizard (highest elevation collected, 8000 feet); and the desert short-horned lizard (highest elevation collected, 8500 feet). Amphibians were searched for in nearby stock-watering areas, but none was found.

Collections of reptiles and amphibians have been made in the Parachute Creek valley, which is approximately 10 miles southeast of the Multi-purpose Spur Corridor. The collared lizard, western rattlesnake and



(The 0-mile point is the meteorological tower on Tract C-b.)

Figure XIV—5 DEER PELLET GROUP COUNTS MULTI-PURPOSE SPUR CORRIDOR

racer have been identified in the lower Parachute Creek valley. The following additional species have been reported for this same locality: gopher snake, side-blotched lizard, eastern fence lizard, plateau whip-tail, tree lizard, great basin spadefoot and Woodhouse's toad.

d. Rare and Endangered Species

There is little probability of any nationally endangered mammalian species occurring in the vicinity of the Multi-purpose Spur Corridor, or within the total study area (Figure XIV-1). The black-footed ferret is the only mammal presently on the nationally endangered list that has been reported in the Piceance Creek basin (one mile from Meeker in 1910, according to the U.S. Department of the Interior, 1973). The black-footed ferret is believed to be primarily a predator of prairie dogs. The white-tailed prairie dog has been reported at only one locality within the study area, in the Parachute Creek valley (Stoecker 1974), but the local population is too low to represent any significant prey base. The nearest white-tailed prairie dog colonies of any appreciable size are near Highway 6 between Grand Valley and DeBeque, and near Highway 64 along the White River at the mouth of Piceance Creek.

Three endangered species are recognized in the State of Colorado: the gray wolf, river otter and wolverine; none is known to occur in the Piceance Creek basin.

The closest reported occurrence of the nationally threatened spotted bat is 300 miles southwest, in Bryce Canyon (Upper Colorado River Comprehensive Framework Study, 1971).

Rare species of special interest that may possibly be found in the study area include the mountain lion, black bear, ringtail and kit fox. The closest known reports of mountain lion and black bear in the past several years were occasional sightings by local residents near West Fork Parachute Creek. Ringtails have been reported in the lower canyon area of Middle Fork Parachute Creek. Kit fox (or swift fox, the taxonomy is confused) have reportedly been trapped near Grand Valley by local residents in years past. No recent evidence of their presence within the study area is available.

e. Wildlife Habitat Types

In view of the need to evaluate alternate corridor routes in addition to the Multi-purpose Spur Corridor, it becomes necessary to extrapolate to some extent from wildlife data gathered in the general region. The regional area of concern is roughly the southeastern quarter of the Piceance Creek basin, through which the several alternate corridors are routed (Figure XIV-1). In order to facilitate describing what is currently known regarding wildlife distributions (particularly terrestrial vertebrate species), categories of wildlife habitat types which are applicable to this entire area (approximately 3000 square miles) have been defined. Six major units have been recognized, consisting of 19 wildlife habitat types. These habitat types are discussed later.

The major objective of the wildlife habitat map for the multi-purpose spur (Figure XIV-6) is to delineate land surface units appropriate to animal ecology. Ecology, in its traditional meaning, is the science of the interrelationships between organisms. The interrelationships considered to be most relevant with regard to wildlife are: 1) animal-plant associations; and 2) certain physical features of the environment which might provide such elements as nest sites, travel routes and protection during severe weather. Although vegetation maps come close to satisfying the needs of the animal ecologist, the units appropriate to plant ecology are often too finely divided to encompass an assemblage of animal species, especially as these tend to shift seasonally.

The wildlife habitat map for the Multi-purpose Spur Corridor (Figure XIV-6) was developed simultaneously with the habitat map for the Tract (Figure V-29). Consequently, both maps have the same objectives, the same regional orientation and the same intended application. Both emphasize the more important bird and mammal species as defined on the basis of aesthetic, economic or ecologic criteria. The following brief descriptions of the 19 habitat types, therefore, apply to both maps, even though only seven of the 19 habitat types are represented along the Multi-purpose Spur Corridor.

(1) Riparian Areas

- Streamside vegetation and marsh. This habitat type occurs in moist zones along the margins of permanent and ephemeral streams, or near springs, seeps and ponds. Such areas have a limited and scattered distribution, and are typically vegetated by various semi-aquatic sedges, rushes, grasses and herbs.

- Cottonwood groves. Few stands of cottonwood trees occur within the southeastern quarter of the Piceance Creek basin. Most stands are represented only by several trees, yet these should be recognized as a habitat type of potential significance, especially to avian species.

- Open Water. The open water of ponds and streams is singled out from riparian areas because of its importance to waterfowl, beaver and certain other semi-aquatic wildlife.

(2) Lower Valleys (below 6500 feet)

An elevation of 6500 feet was chosen as the most appropriate center point of an altitudinal zone frequently observed as separating many avian and mammalian species. This elevation, although to some extent arbitrary, has proved applicable during both summer and winter. Also, this elevation is a fair approximation of the upper portions of deer winter range as it occurs in valleys. The same winter range boundary is nearer to 7500 feet on the ridges, however, which tend to have reduced snow accumulation because of the influence of wind and topography.

- Agricultural meadows. Various hay meadows and pastures occur along the floodplains of the major streams at the lower elevations. Most are irrigated, productive and often an important component of deer winter range.

- Lower slopes and bunchgrass. Lower slopes of valleys are frequently vegetated by Indian ricegrass and scattered pinyons and junipers. The south-facing slopes are especially important to deer during times of deep snow.

- Bottomland shrub and bottomland sagebrush. Shrub communities, generally rabbitbrush, greasewood and big sagebrush, typically occur at the base of the lower slopes. Occasionally these shrub communities extend onto the valley floors.

- Lateral draws. Small, steep-sided draws that cut perpendicularly into larger valleys are common topographic features, especially at lower elevations. They are characterized by a steep, intermittent drainage channel that dissects the bedrock at the beginning of the draw and forms a steep-sided channel through the alluvium at the bottom. The usual vegetational pattern is dense, big sagebrush covering a small alluvial fan; mixed mountain shrubs on northern exposure (bitterbrush, mountain mahogany, serviceberry, occasionally oak); and bunchgrasses with scattered pinyons and junipers on the southern exposures. These draws have a particular significance to deer, at least in the vicinity of the Tract, providing both food and shelter during extreme winter weather.

(3) Upper Valleys (above 6500 feet)

- Agricultural meadows. These meadows in the upper valleys are similar to those at lower elevations, but in terms of many wildlife species, snow cover is likely to be an overriding factor that contributes to differential usage.

- Lower slopes and bunchgrass. Lower slopes at the higher elevations tend to support a narrower zone of bunchgrass because of the continual downward encroachment by mixed mountain shrub.

- Bottomland sagebrush. Perhaps the most conspicuous difference between the lower and upper valley areas is the extensive and very homogeneous stands of big sagebrush which frequently replace agricultural meadows on the valley floors. Additionally, greasewood is absent at these higher elevations.

(4) Pinyon-Juniper

- Rimrock. Most of the sandstone cliffs and ledges occur in close proximity to pinyon-juniper woodlands. These areas provide important denning and nesting areas for both birds and mammals.

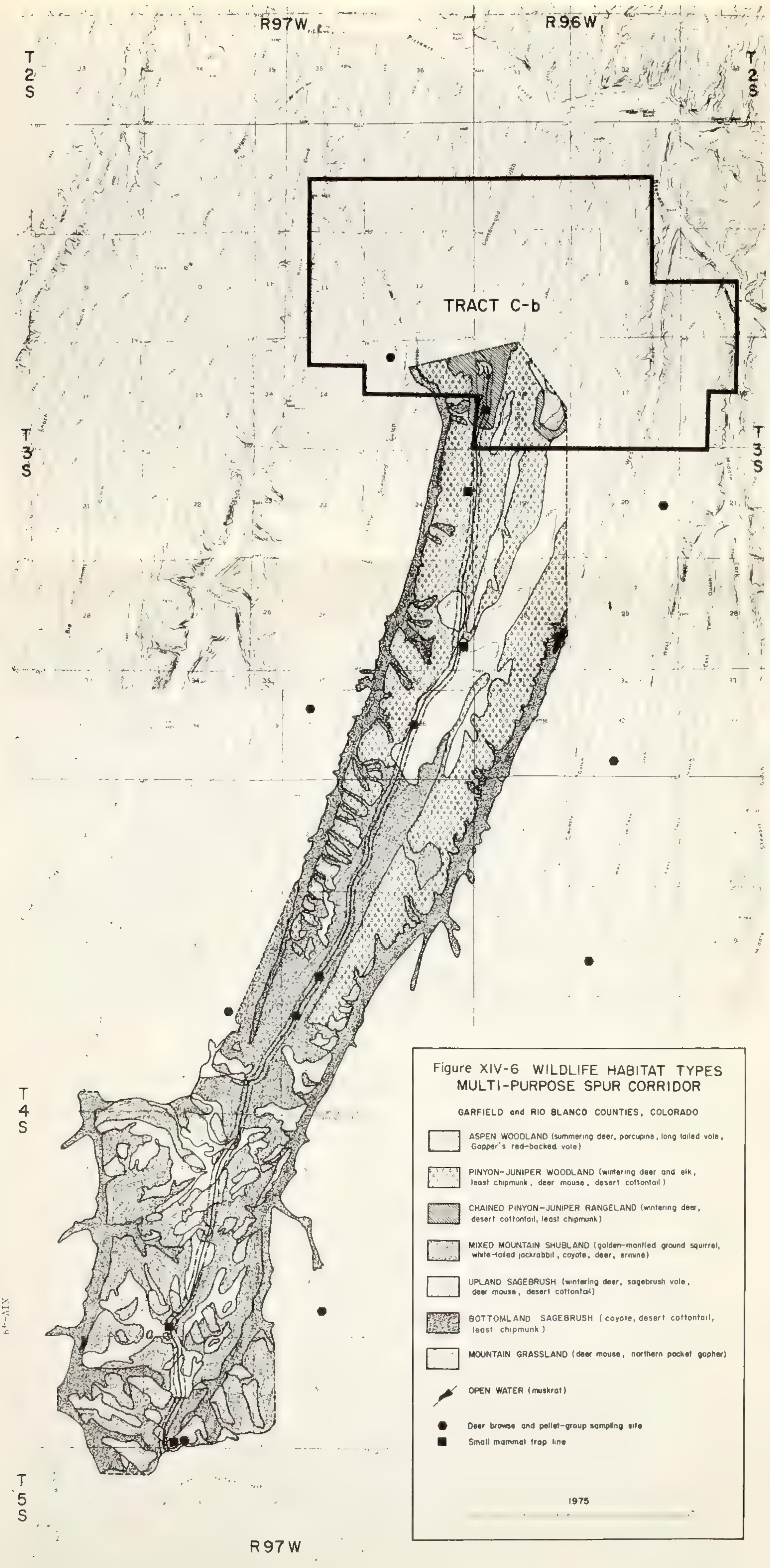


Figure XIV-6 WILDLIFE HABITAT TYPES MULTI-PURPOSE SPUR CORRIDOR

- Pinyon-juniper woodland. These woodlands occur over wide areas. Understory vegetation varies considerably, with some stands having dense shrubs or grasses and others being more open and sparsely vegetated. The common understory includes big sagebrush, mountain mahogany, bitterbrush, snowberry and serviceberry.

- Burned areas. Old burns occasionally occur within the pinyon-juniper woodlands. The clearings that result are usually characterized by widely spaced dead trees and a ground cover in which Indian ricegrass is dominant.

- Chained pinyon-juniper rangeland. The chaining program of the BLM has created large blocks of open areas within the pinyon-juniper woodland. These areas are distinctive, consisting of fallen trees with shrubs and grasses characteristic of the understory of pinyon-juniper woodlands.

- Upland sagebrush. Big sagebrush is a dominant plant species at many sites, both on ridges and valley bottoms. As used here, upland sagebrush refers to the extensive stands of big sagebrush that occur as clearings within or near pinyon-juniper woodland and frequently at higher elevations.

(5) Upland Shrub and Grassland

- Mixed mountain shrubland. Higher elevations are dominated by shrubby species, including big sagebrush, mountain mahogany, serviceberry and bitterbrush. Small stands of mixed mountain shrub also occur at lower elevations on the north slopes of the lateral draws.

- Mountain grassland. These grasslands have a limited distribution at the higher elevations. Typically they occur on convex slopes and are composed largely of needle-and-thread grass, western wheatgrass and Junegrass.

(6) Mountain Forests

- Douglas-fir forest. Isolated stands of Douglas-fir occur at the higher elevations, and occasionally as low as 6500 feet. In most cases, they are restricted to cooler north-facing slopes.

- Aspen woodland. Aspen stands have much the same type of distribution as the Douglas-fir forest. Both tend to occur as discrete plant communities at higher elevations.

3. Other Corridors

In order to evaluate the significant characteristics of each of the three corridors other than the Multi-purpose Spur Corridor, as they relate to wildlife, it will be necessary to supplement the data collected along the Multi-purpose Spur Corridor with data gathered elsewhere. It will also be necessary to use the available literature to the extent possible.

Table XIV-13 was developed to apply the 19 habitat categories described in Section XIV.D.2.e. to a geographic area encompassing the southeastern quarter of the Piceance Creek basin, and to predict occurrences studied. It is, therefore, an application of the habitat maps developed for the Multi-purpose Spur Corridor (Figure XIV-6) and for the Tract (Figure V-29). It should be emphasized that a clear separation is made regarding known occurrences of mammals and expected occurrences, This important distinction retains objectivity and at the same time permits extrapolation.

a. Preferred Water and By-products Corridor

This route extends from Grand Valley to the Colony property at the head of Parachute Creek, and continues along the divide road to the upper end of the Multi-purpose Spur Corridor, then north to the Tract (Figure XIV-1). Wildlife studies have been completed along sections of this route from: 1) the highest point of the Multi-purpose Spur Corridor to the Colony property; and 2) from that location down Parachute Creek valley.

For simplicity, the entire route will be discussed as a unit, based on the literature cited and on recent experience with migratory deer behavior and coyote distributions along the Piceance Creek/Parachute Creek divide (See Quarterly Data Reports). The corridor section from the Multi-purpose Spur Corridor to the Colony location is within deer and elk summer range. The elevation varies from approximately 8200 to 8500 feet. The major habitat types likely to be traversed by the corridor route are mixed mountain shrubland and aspen woodland.

The characteristic mammals present on the Roan Plateau include mule deer, golden-mantled ground squirrel, Eutamias chipmunks, pocket gopher, desert cottontail, deer mouse, coyote and porcupine. These species also are present along the route between the Multi-purpose Spur Corridor and the Colony location. The porcupine should be considered uncommon, although more of this species are encountered in the mixed mountain shrubland habitat than might be expected. The "Eutamias chipmunks" mentioned are difficult to identify. At the present only E. minimus has been identified at these higher elevations. E. umbrinus and E. quadrivittatus occur at lower elevations, and they may occur along this corrdior route as well. Similarly, the species distributions of cottontails and hares are in need of clarification, but efforts thus far have been slowed by generally low densities.

Little is known concerning the number of elk and the frequency that black bear and mountain lion are found in the vicinity of the upper corridor section. There are, however, several regional density estimates available for each of these species. However, these are somewhat speculative because of a scarcity of observed sightings. Three elk were observed near the upper termination of the Multi-purpose Spur Corridor during August 1975 field work. This upper corridor section was also surveyed by air during the previous winter. Five flights were conducted

Table XIV–13 HABITAT AFFINITIES OF MAMMALS IN THE SOUTHEASTERN QUARTER OF THE PICEANCE BASIN.

Mammals	RIPARIAN AREAS			LOWER VALLEYS (below 6500 ft.)				UPPER VALLEYS (above 6500 ft.)			PINYON-JUNIPER				UPLAND SHRUB & GRASSLAND		MOUNTAIN FORESTS	
	Open water	Streamside vegetation & marsh	Cottonwood grove	Agricultural meadow	Lower slopes & bunchgrass	Valley shrub & valley sagebrush	Lateral draws	Agricultural meadow	Lower slopes & bunchgrass	Valley sagebrush	Rimrock	Pinyon-juniper woodland	Burned areas	Chained pinyon-juniper rangeland	Upland sagebrush	Mixed mountain shrubland	Mountain grass-land	Douglas-fir forest	Aspen wood-land
Wandering shrew		—																—	●
Desert cottontail		●	—	●	—	—	—	—	—	—	—	●	—	—	—	●	●		
White-tailed jackrabbit				●	—	—	—	—	—	—			—	—	—	●	●		
Apache pocket mouse					●				●			o		o	o				
Beaver	●	●	●																
Bushy-tailed woodrat		●			●	●	—		—	—	●	●	—	o	—	—	—		
Canyon mouse**					●				o										
Chickaree																		●	
Deer mouse		●	—	o	o	o	—	o	●	o	o	●	—	o	●	●	●		
Gapper's red-backed vole																		—	●
Golden-mantled ground squirrel					●	●	●		●	●	●	●	—	●	●	●	●		
House mouse**		●		●															
Long-tailed vole					—		—		●			—	—	—	—	—			●
Least chipmunk					o	o	—		—	o	o	o	—	o	●	●			●
Montane vole		●		●				—											
Muskrat	●	●																	
Northern pocket gopher				●		●	●	o	●	●			●			●			●
Porcupine												●				●		●	
Richardson's ground squirrel				o				●											
Rock squirrel**				●	●	●													
Sagebrush vole														o	●				
Thirteen-lined ground squirrel																●	●		
White-tailed prairie dog				●															
Yellow-bellied marmot		●		●	●			—	—										
Badger				●	●														
Bobcat									●	●	●	●							
Coyote		●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	—	—
Ermine		—		—				—						o		●			—
Gray fox		●	—																
Long-tailed weasel		●														—			
Raccoon	●	●	●	●				●											
Striped skunk		●	—	●															
American elk							●					●	●		●	●	●	—	—
Mule deer		●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●

* ● species documented by Stoecker-Keammerer & Assoc.

o species documented by Woodward-Clyde, Inc.

** Identified only in the Colorado River drainage.

(Lines represent the usual or characteristic habitat; dots and circles represent documented occurrences.*)

over fresh snow (one each month from December 1974 to April 1975) as part of a winter deer study for the Tract. This upper corridor section was traversed twice during each flight, but no elk, bear or lion were sighted.

Investigations were made over a three-month period in the Parachute Creek valley during the summer of 1973, followed by a deer road-count study during the winter months. The ecology of this spectacular canyon is considerably different than that of the plateau, with faunal associations reflecting desert as well as montane environments. Four species of mammals were identified in the Parachute Creek valley that are unknown at the higher, plateau elevations (the rock squirrel, white-tailed prairie dog, canyon mouse and house mouse). Wintering deer occur in high concentrations on the valley floor during the fall-through-spring period.

b. Alternate Water Corridor

This corridor would contain a possible water pipeline route from the White River near Meeker, Colorado, along Sheep Creek to Fourteenmile Creek, then to Piceance Creek, and along the Piceance Creek highway and south to the Tract (Figure XIV-1).

The proposed routing of this corridor is along valley floors throughout the entire length. The habitat types traversed consist principally of the upper and lower valley units, each with their component habitat types (Table XIV-13). Deer usage of the upper valleys is likely to be high during fall and spring. The lower valleys become more important during winter.

Considerable data were gathered on winter deer distributions along the highway from the confluence of Fourteenmile Creek with Piceance Creek to the Tract (See Quarterly Data Reports). During fall and spring, large concentrations of deer frequently were sighted in the agricultural meadows adjacent to the highway, and particularly at the lower extreme of this corridor route, from Collins Gulch to Hunter Creek. While the largest deer concentrations have been observed in these lower sections (up to 208 in a one-mile interval), deer also are seen in close proximity to the road throughout the length of the highway to the Rio Blanco Store.

Observation of wintering deer has not been conducted along Fourteenmile Creek. It is likely, however, that this valley represents excellent deer habitat and probably is used by deer during most of the snow-free season.

The 16-mile corridor route from the junction of Fourteenmile Creek and Highway 13/789 to Meeker traverses extensive agricultural meadows and bottomland sagebrush habitats. Deer are commonly seen here during the fall and spring. This section of the corridor route has long been recognized as important deer habitat, and early reports of migrating deer describe impressive fall and spring movements across the Sheep

Creek drainage. Many deer still cross Highway 13/789 during these seasons; records of road-kills in this section have been accumulated by the Colorado Division of Wildlife.

Two additional game mammals probably can be found along this corridor route: the cottontail rabbit (perhaps two species) and the elk. Many nongame species also undoubtedly occur, as indicated by the mammalian species to be expected in the upper and lower valley areas (Table XIV-13). It seems unlikely, however, that any unusual wildlife species or critical habitats occur in this corridor route.

c. Transportation and Alternate By-products Corridor

This corridor is the highway route from Rifle to the Rio Blanco Store and then to the Tract (Figure XIV-1), a distance of approximately 40 miles. The habitat types and the mammalian fauna along the 10 miles of this corridor route that is nearest the Tract have been discussed in the previous section, Alternate Water Corridor.

Although this highway route was driven many times in conjunction with investigations on the Tract, no systematic sampling has been conducted along the route. From vehicles, numerous deer and other wildlife have been observed however, and such observations, along with the data in Table XIV-13, will be used to evaluate existing conditions.

Fewer deer occur along the southern portion of the corridor route, south of the Rio Blanco Store, than along the northwestern portion near the Tract. The major habitat types encountered north of Rifle are lower valley agricultural meadow and bottomland sagebrush. Mixed mountain shrubland becomes more abundant at the higher elevations. Oakbrush is found near the divide 15 miles north of Rifle and seems to be more abundant in this area than elsewhere in the southeastern Piceance Creek basin.

Several rather conspicuous mammals are found near Rifle which are rare or entirely absent near the Tract. For example, gray fox are occasionally seen along roads and nearby on the river terraces of the Colorado River; this species does not occur near the Tract. The rock squirrel is common near Rifle, and very common near Grand Valley. However, it appears that the northward extension of the rock squirrel's range has been limited by the oil shale cliffs. No records are known of this species being found in what appears to be suitable habitat along the Piceance Creek drainage.

E. Vegetation

1. Introduction

The vegetation along the Multi-purpose Spur Corridor is composed of six major vegetation types: aspen woodlands, mountain grasslands, mixed mountain shrublands, big sagebrush communities, pinyon-juniper woodlands and chained pinyon-juniper rangelands. All of these types are common in this portion of the Piceance Creek basin.

On the lower portion of the corridor route, the different vegetation types are distributed along an elevational gradient. Pinyon-juniper woodlands give way to big sagebrush communities and mixed shrublands. At the upper end of the corridor, where the ridge becomes more narrow, the vegetation is much more complex and the overall pattern of vegetation becomes much more patchy. At the lower end of the corridor, the plant communities occur in broad homogeneous areas with much reduced total complexity.

In the descriptions which follow, each of the plant communities is discussed with regard to general location and distribution; structure and composition; stability, diversity and succession; environment; and current land use and management.

2. Methods

a. Vegetation Mapping

The vegetation map of the corridor route (Figure XIV-7) was produced using a combination of air-photo interpretation and field checking. The dimensions of the study area (400 feet by 11 miles) result in considerable difficulty in presenting meaningful graphic and ecological representation of the communities along the corridor route, especially at a scale of 1:24,000. Since impacts on vegetation may occur outside the 400-foot corridor strip, the map was expanded to include surrounding vegetation. The expanded map will also be useful in evaluating various routing alternatives and in identifying locations of potential impacts.

b. Vegetation Sampling

Following general reconnaissance of the area, one representative stand of each vegetation type was selected for sampling. For woodland types, the tree structural and compositional data were obtained using the quarter method. Shrub layers in all communities were sampled using Lindsey's line-strip method, in order to estimate shrub cover, frequency and density. Shrub species were serially ranked on the basis of importance value, a synthetic index derived as a sum of relative cover, relative frequency and relative density. Herb layers were sampled using a quadrat method. Frequency values were determined on the basis of the number of plots of occurrence for each species, divided by the number of plots. Cover values for each species were made by visual estimates in each of the 1- square-meter quadrats. Herb layer species were serially ranked on the basis of importance value, which in this case was equal to the sum of relative cover (percent composition) and relative frequency.

3. Aspen Woodlands

Aspen woodlands are a relatively common vegetation type at the higher elevations in the Piceance Creek basin. They occur mostly on northerly facing slopes, the same exposures which support Douglas-fir forests in the extreme southeastern portion of the basin. Along the

corridor route, the aspen woodlands occur at elevations above 8000 feet and become more fully developed as elevation increases (Figure XIV-7). Distinct boundaries separate the aspen stands from the sagebrush which occurs on opposing slopes and ridgetops (Figure XIV-8).

The aspen woodlands are the most distinct communities which occur along the corridor route, including many species which are not found in the other vegetation types. Also, many of these species, such as blue columbine (*Aquilegia caerulea*), are more commonly encountered in upper montane and subalpine plant communities.

The tree layer within the woodlands is composed almost entirely of aspen (*Populus tremuloides*) which occurs at a density of 1254 trees per hectare (508/acre). Tree standing crop, as it relates to basal area, is high (37.3 m^2/hectare) and at this level the aspen woodlands constitute one of the most productive plant communities in the region. The largest aspen trees attain heights greater than 75 feet and tend to grow in the lower portions of the stands. The shorter trees are immediately adjacent to the ridge crests and tree height increases as the downslope distance from the ridge increases. The aspen canopy cover is nearly continuous. Chokecherry (*Prunus virginiana*), usually a shrub, is the only other species which attains tree size.

The shrub layer is dominated by snowberry, which covers 13% of the understory and occurs at a density of approximately two individuals per square meter. Most of the shrubs are short in stature and the larger aspen saplings, serviceberry (*Amelanchier* spp.) and chokecherry individuals stand out clearly. Although only five shrub species were encountered, the total shrub density exceeded 36,000 shrubs per hectare.

The herb layer within the woodlands is very well-developed and is composed chiefly of perennial forbs. Meadow-rue (*Thalictrum fendleri*) was the dominant species followed by sweet cicely (*Osmorhiza obtusa*) and elk sedge (*Carex geyeri*). Only a few annuals were encountered and they were restricted to disturbed sites in the understory.

Aspen woodlands occur throughout Colorado and in many places they form the pioneer vegetation which develops after fires or other disturbances. In the Piceance Creek basin, stands composed only of aspen commonly occur. At higher elevations in the southeastern part of the basin, the north-facing and northeast-facing slopes are dominated by Douglas-fir, which seems better adapted for growth on these sites. Mixed stands composed of both aspen and Douglas-fir also occur. The apsen stands which occur along the corridor route and elsewhere in this portion of the basin show no signs of being successional. Size-class data show that trees of all diameters occur within the woodlands and these, along with sapling density estimates (9253/hectare), indicate considerable stability. The ground layer is covered by fallen logs in various states of decomposition, indicating a long stand history of growth, development and eventual death and decomposition of the aspen trees. No seedlings

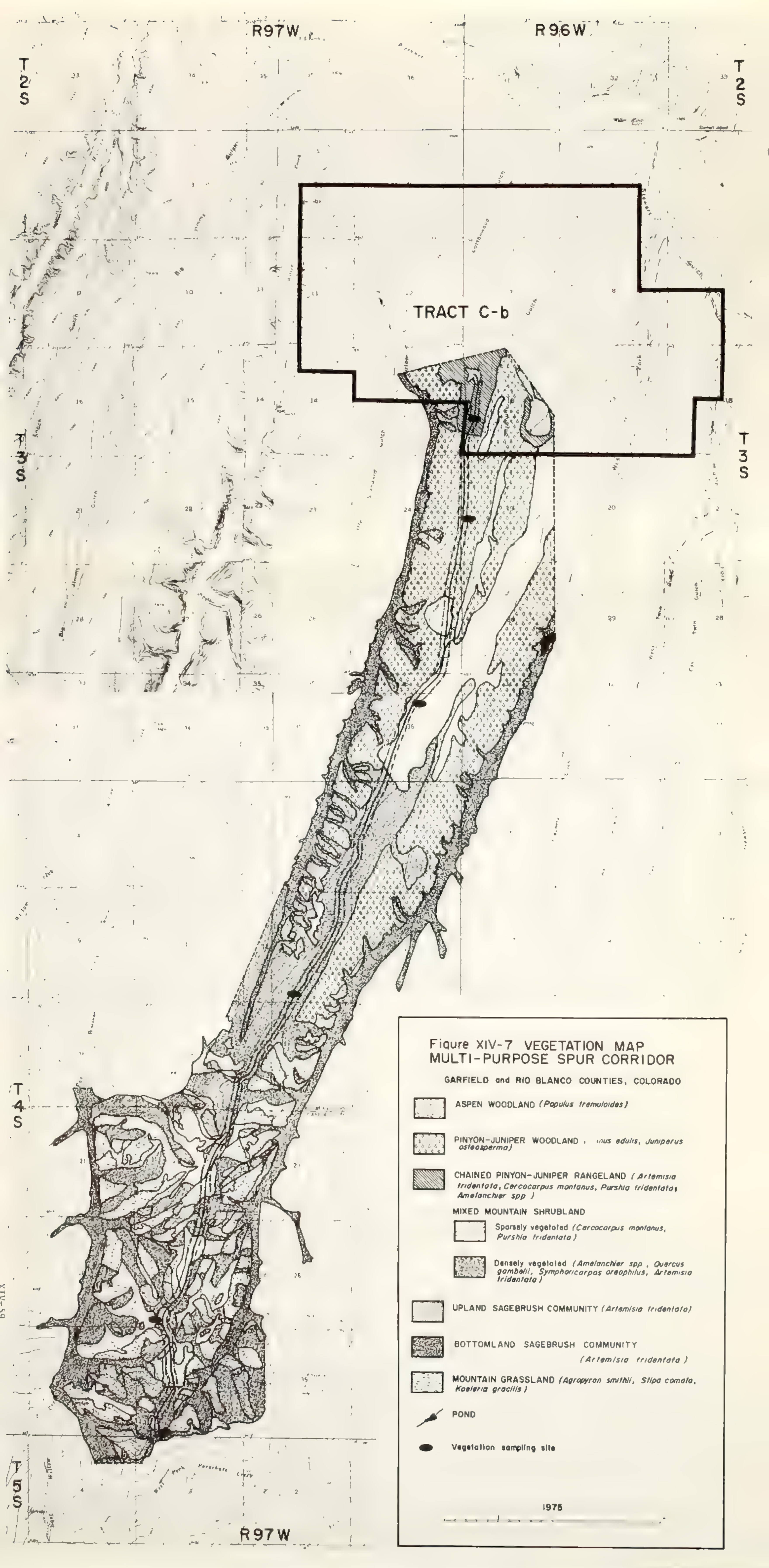


Figure XIV-7 VEGETATION MAP MULTI-PURPOSE SPUR CORRIDOR

Figure XIV–8
ASPEN WOODLAND
ALONG THE
CORRIDOR ROUTE

Figure XIV–9
MOUNTAIN GRASSLAND

Figure XIV–10
MIXED MOUNTAIN SHRUB
COMMUNITY

or saplings of any species likely to replace the aspen were observed. The diversity of shrub species in the aspen woodlands is low compared to other communities along the corridor route. Only five shrub or sapling species were encountered in the sample. Herb diversity, as measured by the average number of species per square meter, was relatively high ($14.4/m^2$) and, as mentioned earlier, the sample included many species not encountered elsewhere.

Although no microclimatic data are available, the aspen woodlands are likely to be the most mesic of the plant communities along the corridor. Large amounts of water are utilized daily by the aspen trees as well as by the dense herbaceous understory. The topographic locations of these woodlands is such that wind-blown snow accumulates in them. Slow melting, resulting from the northerly exposure, allows much of the moisture to percolate downward and to provide sufficient moisture for later in the season when water supply becomes more critical. The sheltered slopes are also likely to be cooler in the summer. The soils in the aspen woodlands are rich, deep and well-developed. High levels of organic matter are evidenced by the black, upper soil layers. This high organic content increases the potential for water absorption.

Even though the tree canopy is nearly complete, there is considerable light which penetrates into the understory; this allows the development of the lush understory. Aspen, are very intolerant of shade and consequently no aspen seedlings were encountered. However, saplings which have developed vegetatively as root sprouts are very abundant, and when openings occur in the canopy as a result of disease or wind throw, the young trees respond to the favorable light conditions and quickly occupy the available space.

Fire seems to play an insignificant role in the ecology of the aspen woodlands along the corridor. Only under extremely dry conditions would the aspens burn. Fires in coniferous forest such as Douglas-fir could cause an increase in the extent of aspen regionally, but fires within the aspen stands are highly unlikely.

Currently the only man-oriented use of the aspen woodlands is livestock grazing. The use by cattle is limited, however, owing primarily to the jackstraw effect of the old fallen aspen logs which provide a substantial obstacle for cattle movements. Along the corridor route no other uses were noted for the aspen woodlands. However, in other parts of the basin, aspen were cut and used for fence posts.

4. Mountain Grasslands

The mountain grasslands occur at the higher elevations along the corridor route and are best developed on hilltops and exposed ridges (Figures XIV-7 and XIV-9). These sites have the greatest exposure to dry summer winds and wind-driven ice and snow in winter. Environmental conditions are less severe on the slopes below the hilltops, and on these sites the mountain grasslands give way to mountain shrublands and sagebrush communities.

The species composition of the mountain grasslands shows considerable similarity to the surrounding shrub communities. The species which comprise the greatest percent of the vegetational cover are those which are also herb-layer dominants in the mountain shrublands and big sagebrush communities. The most obvious characteristic of the grassland communities is the almost complete lack of shrubs, which is unusual in this portion of the Piceance Creek basin. Horsebrush (Tetradymia canescens) and winter fat (Ceratoides lanata) are the only shrub species which occur consistently; together they account for 62% of the shrub importance value. Total shrub density is 1613 shrubs per hectare (approximately equivalent to one shrub per 10 square meters). Most of the shrubs are small, less than 1 meter in height, and are inconspicuous in the grassland vegetation.

The herbaceous vegetation in these communities is dominated by perennial grasses (64% relative cover), with Junegrass (Koeleria gracilis) and western wheatgrass (Agropyron smithii) occurring as dominant species. Two semi-shrubs, snakeweed (Gutierrezia sarothrae) and wild buckwheat (Eriogonum lonchophyllum), are common in the grasslands and are both high-ranking species. Although they occur to some extent in other communities, they reach their greatest importance in this vegetation type. Of the 32 species which are encountered in the herb plot sample, the five top-ranking species account for 71% of the total cover and 53% of the total importance value. This condition is repeated in the other plant communities where the dominance is shared by relatively few species, with the remainder of the vegetation comprised of numerous species of reduced importance.

The mountain grasslands are an interesting component of the total vegetational mosaic of this part of the Piceance Creek basin. Most of the communities are dominated by woody species with shrubs occurring as dominants throughout much of the region. The presence of the grasslands in a shrubland matrix raises questions concerning their successional status. It appears that the environmental conditions on the high ridges and hilltops are more severe, especially with regard to moisture conditions. This could be a strong deterrent to shrub growth, thus making the sites available for more drought-resistant species that are characteristic of grasslands. In this regard, these communities can be considered to be in equilibrium with the environmental conditions and are not likely to be replaced by shrub species.

Not surprisingly, shrub diversity is low in the grasslands. Only five species were encountered. Diversity in the herb layer averaged 12.6 species per square meter.

The mountain grasslands are probably the driest of the plant communities along the corridor. Snow accumulation is minimal in the winter because the hilltops and ridges tend to blow free, and strong winds in the summer cause high transpiration rates. The grassland sites are also characterized by high incoming solar radiation. As a result of the sparse plant cover, there is therefore considerable daily fluctuation in

soil-surface temperatures. The soils are shallow, sandy and not nearly as high in organic matter as the soils in the aspen woodlands. No evidence of fire was noted in these grasslands; however, it may be that periodic burning could be an important factor in excluding shrubs from these communities.

The mountain grasslands are used for grazing livestock, and the presence of cattle has had a considerable impact on the vegetation. Semi-shrubs, like snakeweed and wild buckwheat, are much more prevalent in the heavily grazed areas, and total cover by grasses is greatly reduced (Figure XIV-10). The grassland areas are also used as sites for placing salt blocks, and the vegetation in the immediate vicinity of these salt licks is heavily trampled.

5. Mixed Mountain Shrublands

Mixed mountain shrublands represent some of the most widespread and abundant plant communities in the Piceance Creek basin, and are composed of numerous shrub species which are very important for supporting local mule deer populations. Because there are many shrub species which occur as dominants, the structure and composition of this vegetation type varies considerably, depending on slope, exposure, soil conditions and moisture regime. The most typical stands of mixed mountain shrub include serviceberry (*Amelanchier alnifolia* and *Amelanchier utahensis*), bitterbrush (*Purshia tridentata*), and mountain mahogany (*Cercocarpus montanus*), Gambel's oak (*Quercus gambelii*), snowberry (*Symphoricarpos oreophilus*). On some sites, big sagebrush (*Artemisia tridentata*) also plays a dominant role in the vegetation. In addition to these common species, numerous other shrubs may occur to a lesser extent. Gooseberry and currant (*Ribes* spp.), squaw apple (*Peraphyllum ramosissimum*), mountain lover (*Pachystima myrsinites*), Oregon grape (*Mahonia repens*), chokecherry, and skunkbush (*Rhus trilobata*) are all species in this category. Even though typical stands of mixed shrub include many species, there are sites on which communities dominated by a single species develop. For example, Gambel's oak commonly occurs in nearly pure stands and is known locally as oakbrush. Mountain mahogany also occurs as an overwhelmingly dominant species on steep slopes which are relatively dry. In some places serviceberry and big sagebrush occur together as community dominants. The most diverse types of mixed shrublands tend to be located on steep north-facing slopes and usually occur at lower elevations or on more exposed sites than either aspen or Douglas-fir. Shrub-dominated communites, however, are not restricted to these steep slopes and commonly they occur in some form on ridgetops and southerly facing slopes at higher elevations. There seems to be a very well-pronounced relationship between the compositional character of the mixed shrub community and the topographic feature on which it develops.

The mixed mountain shrub communities along the corridor route occur in several forms. The typical mixed mountain shrub (composed of many species) and a sparse mixed shrub community which develops on southerly exposures both occur within the general study area. The only mixed

shrub community which occurs on the ridgetop that is likely to be impacted by development is a community type in which serviceberry and big sagebrush are the dominant species (Figure XIV-7). This community extends for approximately 3.5 miles along the Multi-purpose Spur Corridor route and is replaced very gradually at lower elevations by big sagebrush and pinyon-juniper communities.

The mixed shrub community has the greatest shrub density of all shrub communities along the corridor route (30,635 shrubs/hectare, which is equivalent to approximately 3 shrubs per square meter). Many of the shrubs are less than 1 meter tall, but some of the clumps of serviceberry are nearly 4 meters in height (Figure XIV-10). Total shrub cover is approximately 53% and is provided mostly by serviceberry, big sagebrush and bitterbrush.

Forty-nine species were encountered in the herb plot sample. Lupine (*Lupinus argenteus*) and sulfur flower (*Eriogonum umbellatum*) were the dominant species, and all perennial forbs together accounted for 56% of the relative cover. Kentucky bluegrass (*Poa pratensis*) and needle-and-thread grass (*Stipa comata*) were the most abundant perennial grasses, but in the mixed shrub community grasses are not as abundant as the perennial forbs. The high number of herb species in this community may result from its intermediate position in the elevational gradient. Species characteristic of higher elevations occur along with those that are more common in pinyon-juniper woodlands. Considerable similarity exists between the mixed mountain shrub and big sagebrush communities along the corridor route. A gradual change occurs from the sagebrush communities at lower elevation, where sagebrush is overwhelmingly the dominant species, to the mixed shrub communities on the ridge, where big sagebrush still occurs as a dominant but the vegetation is composed of numerous other shrub species. A similar change in herbaceous species occurs; the species at the lower end of the gradient are better adapted to drier conditions.

The mixed mountain shrublands are in a stable condition and are not likely to change as a result of succession. The clumps of serviceberry require substantial time to develop to their present size, and the presence of smaller individuals indicates the replacement potential for this species. Slight changes in structure and composition occur every year as a result of individual mortality and germination of new plants. However, the species involved in this process are those which currently appear in the community and do not represent directional successional change. The herb-layer diversity is quite high (15.7 species/m^2), as might be expected by the large number of species which occur in the stand.

The mixed mountain shrublands grow in areas that are intermediate in moisture conditions. They are not as moist as the aspen woodlands, nor are they as dry as the big sagebrush, mountain grassland and pinyon-juniper communities. Because of the size of the shrubs, winter snow tends to collect around them, thus preventing windblown losses characteristic of the mountain grasslands. Soils are shallow, high in silt and sand , and low in organic matter.

Solar-radiation intensities vary considerably throughout the community as a result of variations in the canopy structure. The light conditions underneath the clumps of serviceberry are very much like those within a forest and, not surprisingly, species like milkvetch (Lathyrus ochroleucus) and vetch (Vicia americana) are restricted to these locations. On sites where the vegetation is more open and big sagebrush dominates, solar radiation is more intense and those species which are tolerant of these sun conditions predominate (e.g., western wheatgrass).

Fire plays a very minor role in the mixed shrub communities. In very dry years, the possibility exists for fires to occur, but no evidence of past fires was observed. Of the species which occur in the mixed shrub, Gambel's oak is likely to be the more fire resistant.

The mixed mountain shrublands along the corridor are used primarily for grazing cattle during the summer months. Grazing intensities did not appear to be heavy, although evidences of cattle use were observed throughout the entire area. No specific techniques are used in management of these communities.

6. Big Sagebrush Community

Big sagebrush communities are widely distributed throughout the Piceance Creek basin and occur as two structurally different types. On lower valley floors and on alluvial fans, big sagebrush occurs at very high densities and attains heights in excess of 3 meters. Big sagebrush also occurs in early pure stands on ridges and as clearings in the pinyon-juniper woodlands. On these sites, the sagebrush is much smaller in stature and does not reach densities as great as those attained in the bottomland communities. The ridgetop sage communities extend to elevations as high as 8500 feet. Variation in the stature of the sage plants in the valleys and on the ridges results from a number of environmental parameters as well as from possible genetic sub-specific differences. It is of interest that utilization of the sagebrush by deer is much greater on the ridges than in the valleys because of apparent differences in palatability.

Along the corridor route the big sagebrush communities are of the upland type. The communities are situated, in general, at elevations above the pinyon-juniper woodlands (Figures XIV-7 and XIV-11) and below the mixed mountain shrublands. The transitional gradient through these three vegetation types is gradual and consequently boundaries between the types are indistinct. The primary unifying factor is the presence of big sagebrush which occurs as a dominant species in the shrublands as well as a dominant in the understory of the woodlands.

The shrub species which occur in the big sagebrush communities are essentially the same as those found in the mixed mountain shrublands. The total number of herb and shrub species enountered in the sample was less than the number encountered in the mixed shrublands.

Figure XIV–11
BIG SAGEBRUSH
COMMUNITY

Figure XIV–12
PINYON-JUNIPER
WOODLAND

Figure XIV–13
CHAINED PINYON-
JUNIPER RANGELAND

The shrub layer is dominated by big sagebrush, which occurred at a density of 9710 individuals per hectare and covered approximately 18% of the area. Rabbitbrush (Chrysothamnus viscidiflorus) was the second ranking species. The characteristic species of the mixed mountain shrublands occurred to a reduced extent in the sampled sagebrush stand, which indicates the gradual way in which the species composition changes with elevation.

In contrast to the mountain shrublands, the herb layer in the sampled big sagebrush community was composed primarily of perennial grasses, with Junegrass and western wheatgrass occurring as the dominant species. Lupine and sulfur flower, which were so important in the mixed shrubland stand, were very minor components in the sagebrush stand herb layer. Other important species include sheep fescue, needle-and-thread grass and a species of fleabane (Erigeron sp.). A total of 37 species were encountered in the herb-layer sample. One of the interesting features of the sagebrush stand was the relatively high amounts of native annual forbs. These species are apparent only during the early weeks of the growing season and seem to be well adapted to the conditions of early season moisture and late season drought which characterize many of the lower elevation plant communities.

The big sagebrush communities show considerable stability within the shrub layer. All sizes of shrubs including seedlings of the dominant species occur, indicating stability with regard to age classes. The stability and long-standing character of this type are also reflected in the herb layer, where diversity was the highest of any sampled stand (16.3 species/meter^2). Even though a greater number of species occurred in the mixed shrublands, they were not encountered as frequently or consistently as those in the sagebrush stand. The sagebrush vegetation appears to be in equilibrium with the environmental parameters on these sites and is not likely to be replaced by another plant community. The most likely community type which could develop on these sites is pinyon-juniper woodland. Sapling densities of pinyon pine (Pinus edulis) were 242 per hectare, which is high enough to suggest possible replacement. However, the sagebrush stand which was sampled occurs near the upper elevational limit for pinyon pine in this area. The most likely scenario for community change would suggest a vegetation type composed of scattered pine trees in a sagebrush matrix.

The environmental characteristics of the big sagebrush communities are very similar to those of the mixed mountain shrublands. The soils appear to be very much alike; however, the sagebrush sites tend to be somewhat drier.

Solar radiation is most constant throughout the community, mostly because the large clumps of serviceberry are absent from the sagebrush stands. Light intensities are reduced immediately underneath the individual sagebrush plants and provide suitable environmental conditions for the growth of mosses and lichens. Snow collection and branch runoff are also important factors; they supply moisture and affect the distribution of lichens and mosses in this community.

Sagebrush management has been a long-standing problem in the Western United States and many techniques have been used to reduce sagebrush abundance. In the Piceance Creek basin, herbicidal spraying, chaining and fire have been used to manage sagebrush communities; however, no management techniques have been utilized along the corridor routes. The current use of this community appears to be restricted to cattle grazing.

7. Pinyon-Juniper Woodlands

Pinyon-juniper woodlands are widely distributed at lower elevations throughout the Piceance Creek basin region. The percentage composition of the two dominant species varies from nearly equal amounts of each to nearly pure stands of either species. In general, stands dominated by juniper (Juniperus osteosperma, and occasionally Juniperus scopulorum), tend to occur at lower elevation, but the reasons for the distributions of the dominant species are more complex than an elevational gradient.

The pinyon-juniper woodlands reach their upper elevational limit along the corridor (Figure XIV-7). The transition is gradual and is characterized by vegetation which is mostly dominated by big sagebrush in which pinyon pines are scattered. The woodlands occur on the ridgetop as well as on the steep slopes.

The pinyon-juniper woodlands that occur along the corridor have open canopies and low tree densities (259 trees/hectare) (Figure XIV-12). Pinyon pine is the dominant species and only a very few junipers occur. The comparison of standing crop (as related to basal area per hectare) between the pinyon-juniper woodlands and the aspen woodlands is striking. Basal area per hectare is nearly five times greater in the aspen woodlands.

The dominant species in the shrub layer are big sagebrush followed by pinyon pine saplings. Total shrub cover is only 8% (approximately one-third of the value for the big sagebrush community). Reduced shrub cover and density is probably the result of competition between the shrubs and trees. The relationship between pinyon pine and elevation can be seen by examining changes in sapling density; the highest density of saplings is reached in the pinyon-juniper woodlands followed by the chained pinyon-juniper rangelands. From the high levels in these two types, the density drops substantially in the big sagebrush and mixed shrub communities, and the species is entirely absent from the communities at the upper end of the corridor route.

The herb layer in the pinyon-juniper woodlands is dominated by sheep fescue, needle-and-thread grass, western wheatgrass and Junegrass, all perennial grasses which account for 62% of the total cover. The herb layer is relatively sparse (total cover is approximately 20%). Thirty-six species were encounted in the herb-plot sample. Of these, the top five species account for 72% of the cover and 52% of the importance value. Most of the species are not very important.

The pinyon-juniper woodlands are one of the most stable of the plant communities in the area. In other plant communities, stability and community age may be estimated indirectly by examining diversity and structural data. With pinyon-juniper woodlands it is possible to establish minimal community ages by dating the oldest trees. Studies in the area have shown that the oldest trees are more than 500 years old (Third Quarterly Data Report 1975). The trees are rarely taller than 35 feet, but the largest trees are more than 2.5 feet in diameter at breast height. Herb diversity is low, with an average of only 9.5 species per square meter.

The pinyon-juniper woodlands occur mostly on dry rocky sites. Soils are primarily silty-sandy and shallow. With the bedrock close to the surface, both major tree species are shallowly rooted. Pinyon-juniper woodlands also occur on north-facing slopes where microclimatic conditions are much more favorable. On these sites a more dense understory develops which contains herb species characteristic of mixed mountain shrublands. On more rocky exposed sites, the combination of limited soil moisture and competition for sunlight probably limit understory development.

Fires occur occasionally in the pinyon-juniper woodlands. Several old burns occur in the region and recovery from fire seems to be slow. On burned sites, Indian ricegrass grows abundantly and seems well adapted to post-fire conditions.

The pinyon-juniper woodlands are currently used for grazing. The limited herb-layer production provides relatively poor forage. Additionally, young juniper trees are cut for fence posts. Pinyon-juniper woodlands are managed by chaining in order to increase forage for livestock. With this technique, all trees are knocked down in order to increase production in the herb and shrub layers. The vegetation type which develops after chaining is discussed more fully in the following paragraphs.

8. Chained Pinyon-juniper Woodlands

The chained pinyon-juniper rangelands constitute a highly variable, somewhat artificial vegetation type. They have been produced through management practices of the BLM, which is also responsible for selecting sites to be chained. The chained rangelands occur sporadically throughout the Piceance Creek basin, but they are mostly restricted to ridgetops and gentle slopes where it is possible to operate the chaining bulldozers (Figure XIV-7).

The general appearance of the chained rangelands is a shrubland in which there are many fallen trees (Figure XIV-13). Shrub and sapling cover is only 13%. Dominant species include snowberry and mountain mahogany. Saplings of pinyon pine and Utah juniper are common and form a conspicuous element in the vegetation. The site sampled had been chained approximately 8 years ago, and most of the saplings have grown since that time. There are, however, larger saplings which apparently escaped damage when the site was chained.

The herb layer is composed primarily of the same species which occur in the pinyon-juniper woodlands. However, many of the native perennial species occur at reduced frequency on the chained sites. Cheatgrass, which is a very minor component in the woodlands, ranks third in the chained rangelands. Removal of the tree canopy has resulted in an increase in total herb cover. Based on comparison of the sampled woodland stand and the chained stand, the herb cover on the chained site is approximately 18% greater, and shrub cover is approximately 5% greater.

The chained pinyon-juniper rangelands are ecologically unstable in that they are currently undergoing successional changes. If the successional process is not interrupted, pinyon-juniper woodlands will eventually cover the chained sites. Herb diversity was lowest in the chained sites with an average of only 7.7 species per square meter.

Environmental conditions in the chained rangelands are very much like those in the pinyon-juniper woodlands. The absence of trees in the chained sites results in higher intensities of solar radiation, and also causes drier conditions. The chaining activities caused enough disturbance to the soil surface to allow invasion by many introduced woody species.

Because of all the fallen timber, these sites could be susceptible to burning; however, no evidence of fire was observed.

The chained sites are used primarily for cattle grazing. After chaining, introduced range grasses were seeded on the site to increase forage production. Firewood cutting among the fallen trees is also allowed by permit. This activity removes the larger tree trunks and limbs, but leaves behind most of the branches. Since the site has been chained, no further management activities have occurred on it.

F. Scenics

1. Introduction

This study was undertaken to determine the type and quality of the scenic resources presently existing on the 11-mile-long Multi-purpose Spur Corridor south of the Tract. This corridor is designed to carry shale oil, water, LPG and ammonia pipelines. It will connect the Tract to the Colony pipeline corridor leading to Lisbon Valley, Utah, and, through Parachute Creek valley, to the Colorado River and the Denver & Rio Grande Western Railroad. The objectives of the study were to characterize the scenic elements of the corridor area and to use this information to define and evaluate any areas of visual sensitivity on the corridor route.

2. Methods

The methodology and guidelines used in this study are a modification of those used by the U. S. Forest Service (USFS) in its Visual

Management System (USDA Handbook No. 462), as described in Section XIII, above. The basic components of this methodology are described below.

Landscape elements which contribute to the scenic quality of the area are described in terms of character type and character subtype. Variety classes are identified to take into account any areas which are particularly distinctive or minimal in terms of scenic quality. Human factors, including judgments of the importance of user areas, viewer sensitivity levels and distance zones are included. Detailed descriptions of the method for arriving at these judgments, criteria used, examples of the classes, and illustrations of these subject areas are included in detail in Section XIII above.

3. Results

Figures XIV-14 and XIV-15 show the intensive study area, variety classes and user areas, respectively. A minor modification in the USFS method was made to take into account the fact that the corridor route is not visible from an existing primary travel route in the basin. It is also not visible from the secondary user areas or travel routes located in the adjacent drainages of West Fork Stewart Gulch and East Fork Willow Creek. The only existing travel route from which the corridor route is visible is the three miles of Scandard Gulch road where it reaches the ridgetop between West Fork Stewart Gulch and East Fork Willow Creek. Of course, the corridor will be visible from the maintenance road which will traverse the entire length of the completed pipeline.

The sensitivity level of all areas seen from the corridor route is Level 2, as shown in Table XIII-3 (Section XIII). The distance zone/sensitivity level map shown in Figure XIV-16 should be interpreted as follows: 1) as noted above, the corridor is not visible from most user areas in the Piceance Creek basin; 2) the areas which are visible from the corridor should be considered as vantage points from which one observes the corridor as either foreground, midground or background. Thus concern should focus on maintaining the scenic quality for those who travel the actual corridor route (i.e., the foreground viewers).

The final step in depicting the sensitivity classes which are visible from the corridor was to overlay the variety class map with the distance zone/sensitivity level map. Only those areas which can be seen from the corridor were considered. The USFS method is designed to produce a final map showing visual quality objectives, and recommends the management methods which will accomplish these objectives. In this study the quality objectives have been changed to sensitivity classes so that the final map may be more easily used to consider scenic values in the planning of development. A matrix developed by the USFS was used to arrive at the sensitivity class map. This matrix is shown in Table XIV-14; its function is to integrate the variety classes with the distance zones/sensitivity levels and thus to arrive at the sensitivity classes. The map of sensitivity classes (Figure XIII-17) depicts the baseline scenic quality of the corridor route. When viewed from the corridor

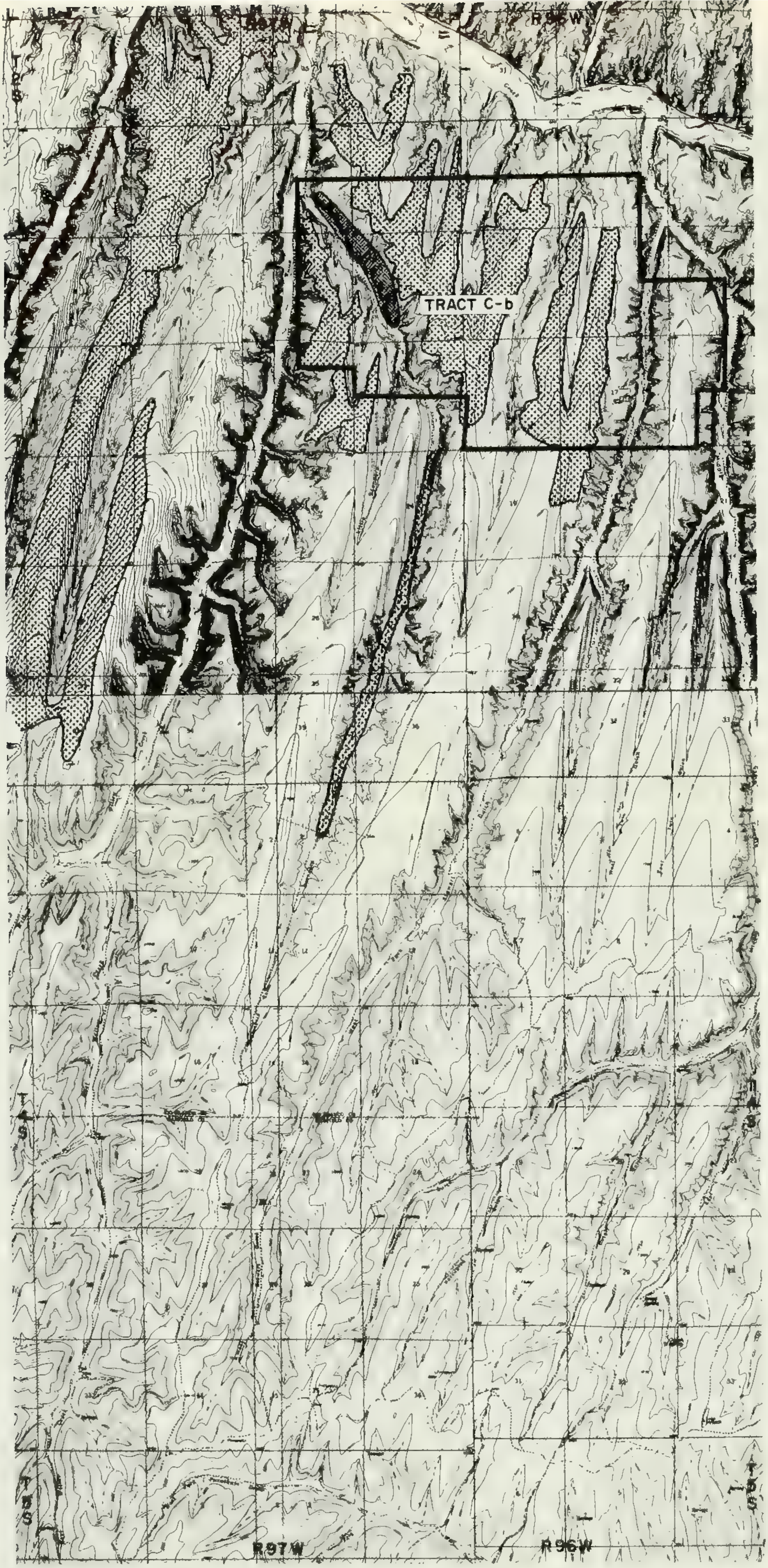


Figure XIV–14 SCENIC STUDY
VARIETY CLASSES

MULTI-PURPOSE SPUR CORRIDOR

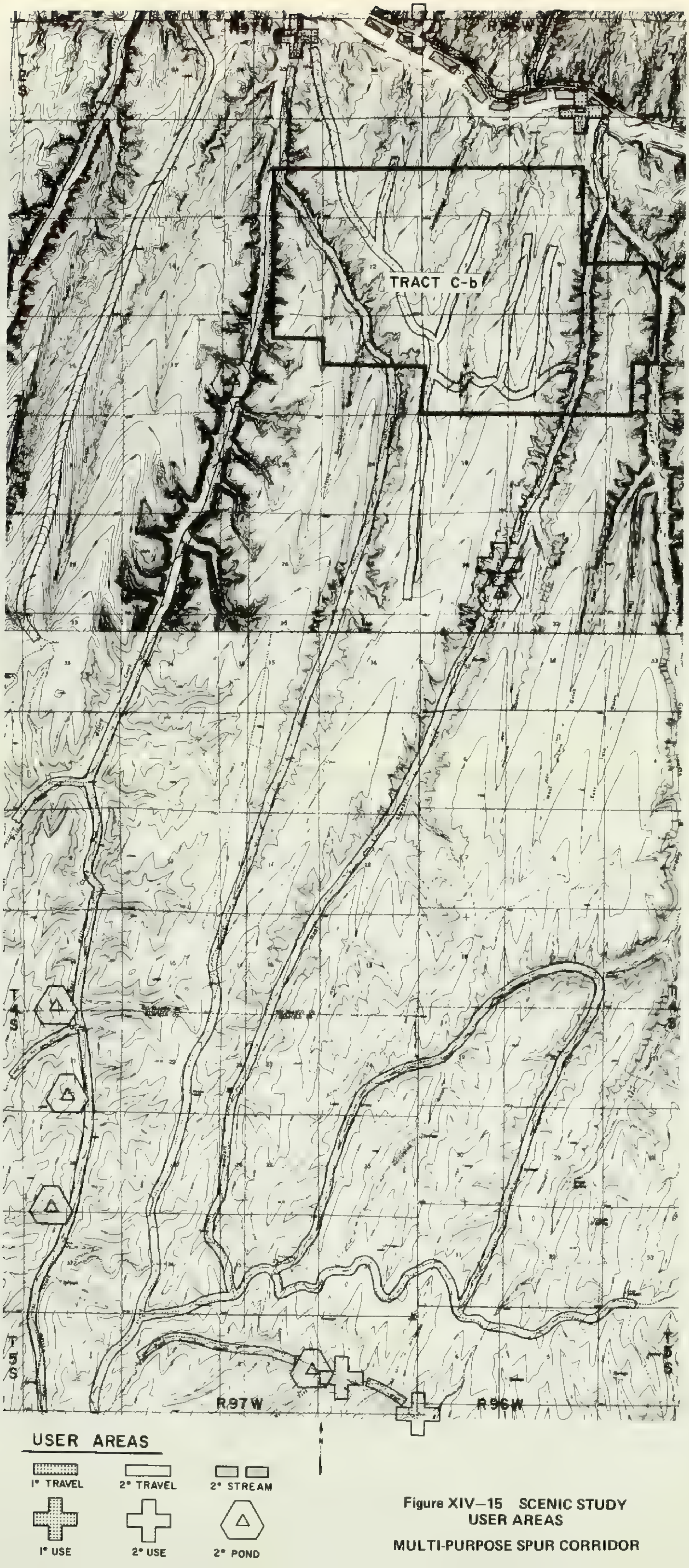
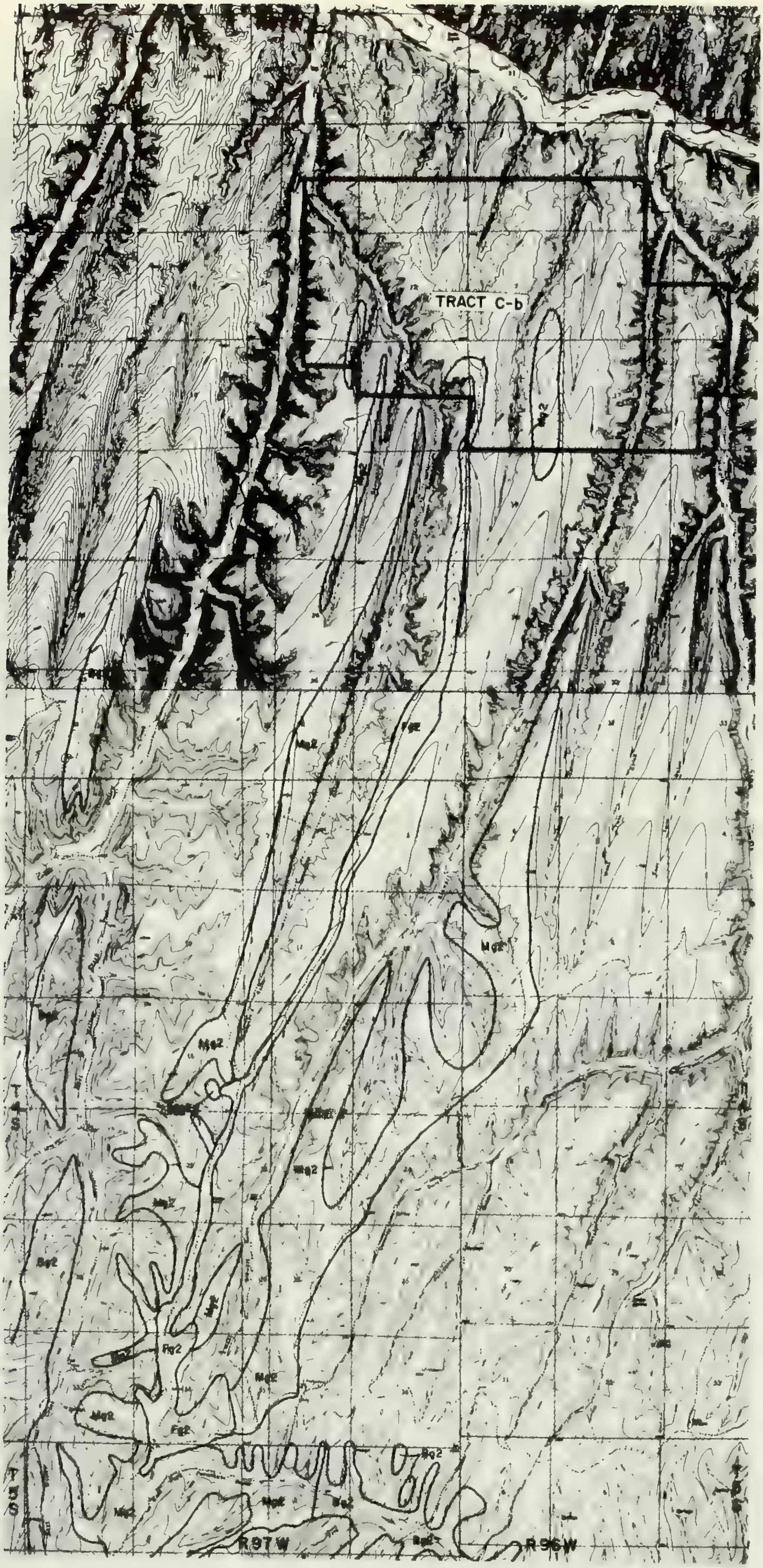


Figure XIV–15 SCENIC STUDY
USER AREAS
MULTI-PURPOSE SPUR CORRIDOR



DISTANCE ZONES

ALL SENSITIVITY CLASS 2

Fg2 – FOREGROUND

Mg2 – MIDGROUND

Bg2 – BACKGROUND

N

Figure XIV–16 SCENIC STUDY DISTANCE ZONES

MULTI-PURPOSE SPUR CORRIDOR

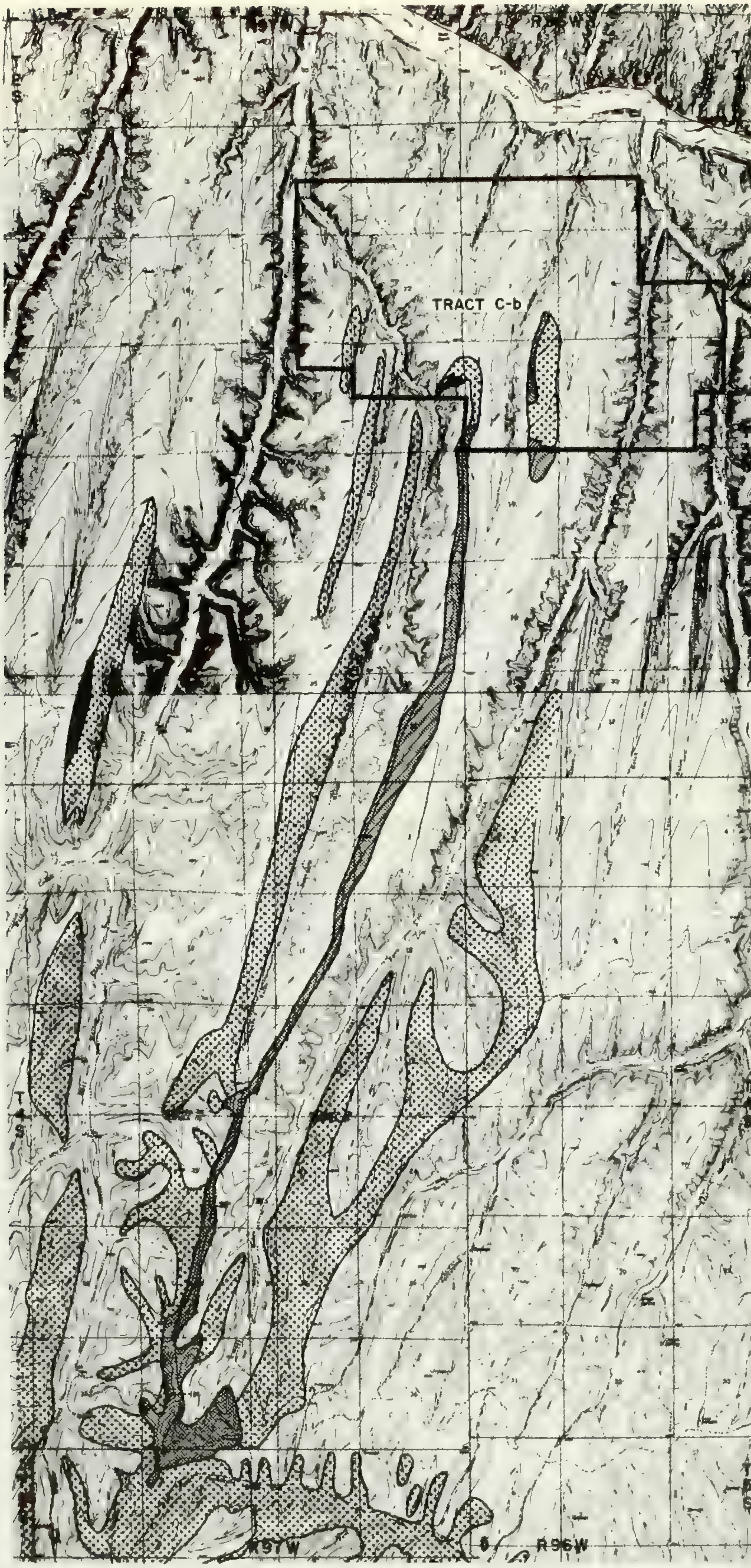


Figure XIV—17 SCENIC STUDY SENSITIVITY CLASSES

MULTI-PURPOSE SPUR CORRIDOR

Table XIV–14 SCENIC RESOURCES SENSITIVITY CLASS MATRIX*

Variety Class	Distance Zone/Viewer Sensitivity Level (for visible areas)					
	Foreground, level 1	Midground, level 1	Background, level 1	Foreground, level 2	Midground, level 2	Background, level 2
Distinctive	A	A	A	B	B	B
Common	A	B	B	B	C	C
Minimal	B	B	C	C	C	D

* Sensitivity Classes

A
B
C
D

Decreasing Sensitivity

proper; the corridor is rated as sensitivity class B. When viewed from all other areas, the corridor is rated sensitivity class C.

The USFS has developed management guidelines for retaining the scenic quality of lands under its control. The Lessee will make use of these same visual management guidelines in all planning, construction and reclamation operations related to the corridor route. In the event that corridor construction must take place in areas of relatively great visual sensitivity, the corridor will be designed to minimize, to the extent possible, the visual impact of the activity. The level of visual sensitivity of each area proposed for corridor routing will be one of several criteria (ecological, economic, hydrological, meteorological, etc.) used in the planning and construction of the corridor. This level will be a factor in determining the degree of design modification necessary to minimize visual impact. The visual management guidelines for each sensitivity class are given in detail in Section XIII.

The major visual impact of the corridor will be related to the sharp edge created as it cuts through the mountain shrub plant communities. Measures to "ruffle" this edge will greatly alleviate the impact. For example, irregular cutting of the edge, as well as saving some shrubs and replanting them in irregular patterns on the corridor, will eliminate the otherwise sharp-edged effect.

4. Summary

The Piceance Creek basin was found to have low scenic value when compared to the other landscape types of the region. The basin contains marginal strength of form and line when compared to nearby Western Colorado areas such as the Book Cliffs, Roan Cliffs, Grand Mesa and the Flattops. It rates about equally with these other types with regard to color and texture. On a regional (much less a national) basis, the Piceance Creek basin has an extremely low degree of visual variety. It should be noted, however, that this lack of variety results in a landscape in which smaller degrees of change are more obvious than they might be in an area which was less uniform.

In the intensive study area surrounding the corridor, the scenic resources were evaluated solely within the context of the Piceance Creek basin itself. A four-level rating scale (sensitivity classes A, B, C and D) was developed based on the USFS Visual Management System. Class C, B and A areas are, progressively, more sensitive than class D areas. Within the context of the basin proper, no class A areas existed on or were visible from the Multi-purpose Spur Corridor. The corridor proper is located on areas determined to be of sensitivity class B. Recommendations were made about means to eliminate the sharp edge created by the corridor right-of-way. This entailed irregular cutting of the edge and random planting of shrubs on the right-of-way.

The assumptions made in this study were designed to maximize the scenic values which do exist in the Piceance Creek basin. It was stated

earlier, however, that these values are in fact marginal when compared to those existing in contiguous areas of Western Colorado.

It should be emphasized that the methodology used here primarily accounts for scenic qualities seen by the majority of basin users. It does not account for areas that the individual hiker or hunter may encounter when traveling off established travel routes. Such areas are subject to extreme individual preferences that no methodology designed to study regional scenic values can accomodate.

G. Soils

Identification of soils and their classification is an important part of understanding the existing environment of the corridor. This information can be used to interpret vegetation distribution and to predict stability of the landscape in the face of disturbance.

All field investigations, descriptions and interpretations are those of the U. S. Soil Conservation Service (SCS), performed during the summer of 1975 in their Piceance Creek basin survey and mapping effort under contract with the BLM. Classification of soils follows the USDA Soil Classification System, 7th Approximation, which was adopted for use by the National Cooperative Soil Survey. The following section is a compilation of SCS results for the specific area of the Multi-purpose Spur Corridor preferred route.

The area treated here lies on the ridgetop to the east, above Scandard Gulch, south of the Tract. Figure XIV-18 is a topographic map of the Multi-purpose Spur Corridor and surrounding area, with the soil series superimposed. Soils are numbered by series and explained in the text. Whenever possible, they were correlated with vegetation type.

Physical parameters for each soil horizon are given in Table XIV-15 These include: color, texture, pH, salinity and depth to bedrock. The typical soil profiles for each soil series are listed in the text with series descriptions and interpretations.

Interpretations of the properties of the different soils on the corridor may be found in Table XIV-16. Fertility was rated for the 15 soils based primarily on organic content. Of lesser importance, but nevertheless controlling soil fertility, are temperature and pH. The K factor is a measure of erodibility and is derived from a nomograph showing particle size, soil structure and permeability. Corrosivity is determined by levels of acidity or alkalinity; acidity corrodes concrete, and alkalinity corrodes steel pipes. Corrosion is estimated for untreated steel pipes in this case, since all soils are above pH 7.0. Shrink-swell potential is related to vertisol clays and is rated low, moderate or high. Drainage capacity is good in all cases. Infiltration is the rate at which water enters soil (i.e., the wetting process). In all the soils in this study it approximates the permeability rate, the

rate at which water passes through the soil. Therefore, only permeability is given. The following is a description of soil series, physical parameters and interpretative material.

1. Parachute Loam 30-75% Slope (2F)

This series occurs at higher elevations on the corridor and has more moisture than lower elevations soils. It is a moderately deep soil supporting a mixed mountain shrub vegetation type. The summer temperature is less than 59°F, thus it has a cool temperature regime. Fertility is intermediate in the range of soil fertility on the corridor. All soil series were ranked in order of organic content, where 1 = highest and 15 = lowest. The K factor shows that erodibility for Parachute is slightly above average for corridor soils. Corrosivity, shrink-swell, drainage and permeability do not show any significant differences from other soils in the area.

Typical Soil Profile

A_1	0-5 inches; dark grayish brown loam (Munsell notation); non-calcareous
B_2	5-13 inches; very dark grayish brown loam; non-calcareous
C_r	13-24 inches; brown fine sandy loam; non-calcareous
R	24+ inches; Green River sandstone

2. Parachute Rhone Loams 5-30% Slope (2CE)

The Parachute-Rhone loams are found on cool north-facing slopes where the vegetation consists of small aspen trees and large shrubs. It is a complex of soils with much variation in depth and with family characteristics intergrading between Parachute Loam and Rhone Loam. In this study the two soils are so intermingled they are mapped as one unit (2CE). Over the area there is 45% Parachute soils, 40% Rhone and 15% Hapgood-like and shallow soils.

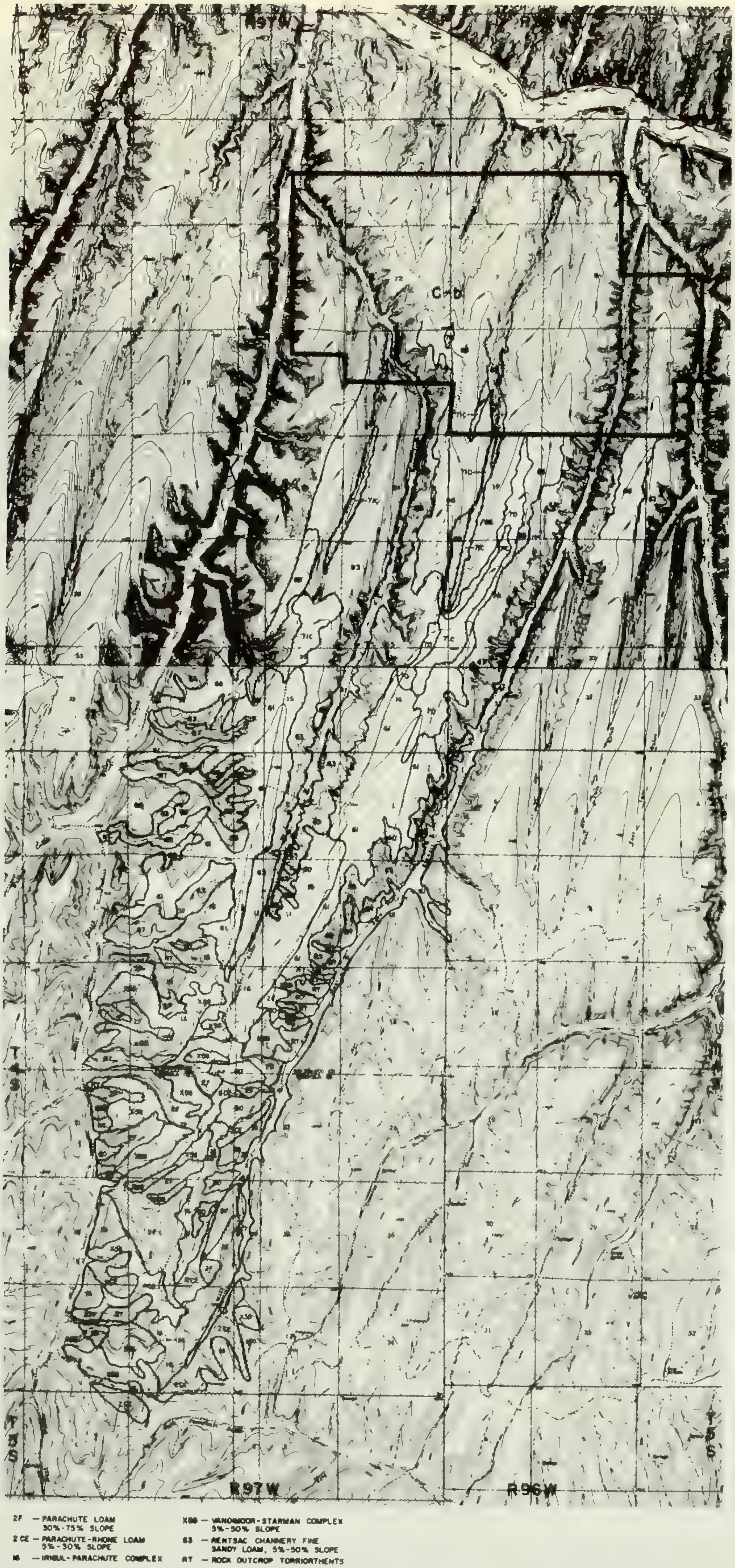
Soil depth varies, but in general, is deeper than the average depth for the corridor. Texture also varies, from loamy skeletal to coarse loamy to fine loamy. Compared to the other soils of the area, this soil is rather fertile and high in organic nutrients. Rhone soils have a notably low permeability.

Typical Soil Profile (Rhone component)

A_1	0-8 inches; dark grayish brown loam; non-calcareous
B_2	8-24 inches; dark grayish brown loam; non-calcareous
B_3	24-42 inches; grayish brown loam; non-calcareous
C_r	42+ inches; brown weathered sandstone

3. Irigul-Parachute Complex (16)

Being a complex intergradation between several soil types, the characteristics of Irigul-Parachute cover a wide range of variation.



2F — PARACHUTE LOAM 30%-75% SLOPE

2 CE — PARACHUTE-RHONE LOAM 5%-30% SLOPE

16 — IRIGUL-PARACHUTE COMPLEX

X6 — NORTHWATER

X7 — SILAS COURSE LOAMY VARIENT

60 — REDTHAYNE-LIKE STONY LOAM

61 — CASTNER-LIKE CHANNERY FINE SANDY LOAM

X68 — VANDAMOOR-STARMAN COMPLEX 5%-50% SLOPE

63 — RENTSAC CHANNERY FINE SANDY LOAM, 5%-50% SLOPE

RT — ROCK OUTCROP TORRIORTHENTS

71 C — FORELLE

70 — PICEANCE

41 — GLENDIVE

66 — REDCREEK-RENTSAC

Figure XIV–18 SOILS MAP
MULTI-PURPOSE SPUR CORRIDOR

Table XIV–15 PHYSICAL PARAMETERS OF SOILS – MULTIPURPOSE SPUR CORRIDOR

Soil Series	Map Unit	Horizon	Depth (in.)	Color	Texture	pH	Salinity
Parachute Loam	2F	A_1	0-5	Dark grayish brown	loam	7.4	low
		B_2	5-13	Very dark gr-br	loam	7.4	low
		C_r	13-24	Brown	fine sandy loam	7.4	low
		R	24	Green R. sandstone			
Parachute-Rhone	2CE	(Rh)A_1	0-8	Dark gr-br	loam	7.4	low
		B_2	8-24	Dark gr-br	loam	7.4	
		B_3	24-42	Grayish brown	loam	7.4	
		C_r	42+	Brown	weathered sandstone		
Irigul-Parachute	16			See Parachute above and Irigul below			
Irigul	X6	A_{11}	0-3	Grayish brown	channery loam	7.2	
		A_{12}	3-12	Grayish brown	very channery loam	7.3	
		CR	12	Light brownish gray	extremely ch loam	7.4	
		R		Fractured sandstone		7.6	
Northwater	X5	O_1	2-0	Litter with decomposition			
		A_1	0-10	Dark gr-br	channery loam	7.2	
		B_{21T}	10-	Brown	very ch loam	7.2	
		B_{22T}	-40	Yellowish brown	extremely ch	7.2	
		C	40+	Yellowish brown	ex ch sandy loam	7.2	
Silas Variant	X7	A_1	0-16	Dark grayish br	fine sandy loam	7.2	
		AC	16-32	Brown	fine sandy loam	7.4	
		C	32-60	Light yellow br	f.s.l. gravelly stratified s.l.	7.4	
Redthayne-like	60	O_1	2-0	Leaf litter		7.8	
Stony Loam		A_1	0-14	Dark gr-br	f. ch. loam	8.0	
		C_1	14-33	Pale brown	extremely ch. f.s.l. 75% coarse fragments	8.4	

Table XIV–15, continued

Soil Series	Map Unit	Horizon	Depth (in.)	Color	Texture	pH	Salinity
Castner-like	61	A_{11}	0-6	Dark brown	very channery loam	7.6	low
Channery Fine		A_{12}	6-10	Dark brown	very channery flaggy l.	7.4	
Sandy Loam		C_{ca}	10-16	Brown	zone of lime accum.		
					with flaggy loam	8.0	
		R	16+	Hard sandstone			
Vandimore–	X58	(Van)A_1	0-4	Grayish brown	channery sandy loam	8.0	
Starman		C	4-22	Very pale brown	extremely ch. s. l.	8.4	
Complex 5-50%		R	22+	Fractured sandstone		8.4	
Slope							
		(St)A_1	0-3	Very pale brown	channery loam	8.0	
		AC	3-10	Very pale brown	very channery loam	8.2	
		R	10+	Sandstone		8.2	
Rentsac Channery	63	A_1	0-11	Pale brown	very ch. s. l.	8.4	
Fine Sandy Loam		C_r	11-18	Pale brown	very flaggy s.l.	8.4	
5-50% Slope		R	18+	Hard fractured sandstone			
Rock Outcrop	RT			Ochric epipedon	channery sandy loam		
Torriorthents							
Forelle	71c						
Piceance	70						
Glendive	41	Described in Section XII					
Redcreek-Rentsac	66						

Table XIV–16 SOILS INTERPRETIVE DATA – MULTIPURPOSE SPUR CORRIDOR

Soil Series	Map Unit	Fertility 1=hi; 15=lo	Erodibility K Factor	Corrosivity*	Shrink-Swell Potential	Drainage Capacity	Permeability Rate in./hr.
Parachute Loam	2F	5	32	moderate	low	good	2.0-6.0
Parachute-Rhone	2CE	2	28	P=moderate R=moderate	low low	good good	2.0-6.0 0.6-2.0
Irigul-Parachute Complex	16	6	32	I=moderate P=moderate	low low	good good	2.0-6.0 2.0-6.0
Irigul	X6	11	32	moderate	low	good	2.0-6.0
Northwater	X5	1	24	moderate	moderate	good	0.2-0.6
Silas Coarse Loamy Variant	X7	3	24	moderate	low	good	2.0-6.0
Redthayne-like Stony Loam	60	4	32	high	low	good	2.0-6.0
Castner-like Channery Loam	61	10	32	high	low	good	2.0-6.0
Vandimore-Starman Complex	RT	13	37	high	low	good	0.6-2.0
Rentsac Channery	63	14	28	high	low	good	2.0-6.0
Rock Outcrop Torriorthents	RT	15	.10	–	–	–	–
Forelle	71c	8	28	high	moderate	good	0.6-2.0
Piceance	70	9	28	high	low	good	0.6-2.0
Glendive	41	7	24	high	low	good	2.0-6.0
Redcreek-Rentsac	66	12	28	high	low	good	2.0-6.0

* Or untreated steel pipe

Some areas show the deep, loamy skeletal soils of the Parachute, with fine or coarse loamy soils in places. In other areas, loamy skeletal material becomes more shallow, like the Irigul Series. Over the area, there is 40% Parachute, 50% Irigul and 10% more shallow soils.

4. Irigul Series (X6)

This is a fairly shallow soil (10-20 inches); it occurs on the upper reaches of the corridor, toward the south. Irigul is the mollic, colder counterpart to the Rentsac series of lower elevations. The vegetation is mostly sagebrush with scattered mountain shrubs. Fertility is low and the soil is shallow.

Typical Soil Profile

A_{11}	0-3 inches; grayish brown, channery loam; weakly calcareous
A_{12}	3-12 inches; grayish brown, very channery loam
CRR	12+ inches; light brownish gray, extremely channery loam; weakly calcareous
R	Fractured sandstone

5. Northwater Series (X5)

Northwater has the highest fertility of any soil in the area and supports the stands of large aspens in the corridor. Its uniqueness is a high clay content; it is the only soil with a defined argillic, or clay, horizon. The depth of this soil is moderate, 20-40 inches, in three-fourths of its area of occurrence. Twenty percent of its area is deeper (40-60 inches), whereas only 5% is more shallow (10-20 inches). Because of its clay content, shrink-swell potential is higher than most of the series soils, and permeability is very low.

Typical Soil Profile

O_1	2 inches deep; litter in various stages of decomposition
A_1	0-10 inches; dark grayish brown, channery loam;
B_{2T}	10- inches; brown, very channery loam
B_{22T}	-40 inches; yellowish brown, extremely channery loam
C	40+ inches; yellowish brown, extremely channery sandy loam

6. Silas Coarse Loamy Variant (X7)

This variant is not a true Silas because it is a coarse loamy soil with a lower clay content (18%). It is a fairly fertile soil and supports sagebrush stands. The outstanding feature of this series is its depth; it is deeper than 60 inches wherever it occurs. It is found in bottoms as alluvial and colluvial deposits.

Typical Soil Profile

A_1	0-16 inches; dark grayish brown, fine sandy loam
AC	16-32 inches; brown, fine sandy loam
C	32-60 inches; light yellow brown, fine gravelly sandy loam stratified with sandy loam.

The three following series are the warmer soils that occur within the Tract study area. They are described above in Section XII. All three have characteristically high corrosivity because of high pH. Permeability is high for these soils.

7. Redthayne-like Stony Loam (60)

See soil (60) in Section XII.

8. Castner-like Channery Fine Sandy Loam (61)

See soil (61) in Section XII.

9. Rentsac Channery Fine Sandy Loam 5-50% Slope (63)

See soil (63) in Section XII.

10. Vandimore-Starman Complex 5-50% Slope (X58)

The Vandimore-Starman Complex is a shallow, lithic soil that occurs on bald knobs. The vegetation is mostly low, with grasses and forbs predominanting. Forty percent of the area designated as Vandimore soils is between 20 and 25 inches deep. Starman soils make up 40% of the area, and rocky soils cover 20%.

Erodibility is higher for this series than for any other soils described. Permeability rate is quite low, and fertility is low, which may indicate a reason for lack of shrubs.

Typical Soil Profile (Vandimore component)

A_1	0-4 inches; grayish brown, channery sandy loam; calcareous
C	4-22 inches; very pale brown, extremely channery sandy loams; calcareous
R	22+ inches; fracture sandstone

Typical Soil Profile (Starman component)

A_i	0-3 inches, very pale brown, channery loam; calcareous
AC	3-10 inches; very pale brown, very channery loam; calcareous
R	10+ inches; sandstone

11. Rock Outcrop Torriorthents (RT)

This is the area of rock lands that is quite shallow, low in

organic material and supports very little vegetation. Torriorthent soils are interspersed with the rock outcrops. Temperatures are generally high. The epipedon is ochric. Fertility is virtually nil and erodibility is not high.

The four following soil series are described above in Section XII.

12. Forelle Series (71C)

See (71C) in Section XII above. Interpretive data indicate this soil has some shrink-swell potential because of the presence of some clay-containing vertisols. Permeability is poor.

13. Piceance Series (70)

See (70) in Section XII above. Low permeability is the only soil characteristic of note.

14. Glendive Series (41)

See (41) in Section XII above.

15. Redcreek-Rentsac Series (66)

See (66) in Section XII above.

H. Archaeology

1. Introduction

Archaeological reconnaissance investigations were made of the Multi-purpose Spur Corridor and Alternate Water Corridor routes (Figure XIV-1). The purpose of these investigations was to identify sites of past human activity and to assess the scientific value and historical significance of each site. The physical reconnaissance of the Multi-purpose Spur Corridor route was conducted September 6-7, 1975. The Alternate Water Corridor route was examined on September 19-20, 1975.

2. Methods

The reconnaissance of the Multi-purpose Spur Corridor route was carried out on foot. Traditional artifact collection techniques were employed on the single site located. No systematization of collection procedures was employed; all of the portable cultural material found was picked up as a general surface collection. No test excavations were made.

The reconnaissance of the alternate route of the water line was done very superficially. The Sheep Creek portion of the route was examined by means of auto travel along Colorado Highway 13/789 between the White River and Fourteenmile Creek. The creek segment was examined on quad-centered aerial photographs and USGS topographic maps with field checks of specific localities. More intensive examination

was not appropriate, as adequately precise definition of the actual alignment of the water line alternate has not been made.

3. Results

A single site, 5GF169, was found in the study of the Multi-purpose Spur Corridor. This site is located on the ridge between West Fork Stewart Gulch and East Fork Willow Creek; it is approximately 1150 feet from the east line and 1700 feet from the south line of Section 22, T4S, R97W, Rio Blanco County, Colorado. No sites were recorded along the Alternate Water Corridor.

Site 5GF169 consists of a meager scattering of flakes representing the waste material from stone-tool manufacture, repair and resharpening. In addition to the industrial waste, a mano, or handstone, used for processing vegetal products, and the basal fragment of a bifacially worked stone tool were recovered from the site. Neither is diagnostic of any particular time period or cultural group. The site has been recorded on an Archaeological Survey of Colorado Inventory Sheet. The artifacts collected and all tools of potential historic or scientific value were described on Colorado State University Catalog forms.

This site is similar to many others which dot the Piceance Creek basin and neighboring areas; for example, there are a substantial number recorded for the Naval Oil Shale Reserve. The site probably served as a seasonal collecting and hunting camp. Judging from its poor material content, it is unlikely to be on or near any prehistoric trail between Parachute Creek and the Piceance Creek basin. The site has no unique features which would warrant nomination to the National Register of Historic Sites.

No other evidence of prehistoric or historic occupation was found along the route of the Multi-purpose Spur Corridor. This is not unusual; site densities in the Piceance Creek basin are quite low and the few sites that do exist are small seasonal camps. The frequency of occurrence of this type of site and the likelihood that it has been seriously disturbed by later occupants have led the investigators to recommend that no further action be taken for its protection.

As noted above, the Alternate Water Corridor route was not systematically examined for cultural resources, and on closer inspection it may yield a number of archaeological sites. The Sheep Creek segment is on the major historic access route between the Colorado and White Rivers. It is also likely to have served as an important travel route in prehistoric times as well. The valley is well watered and has numerous localities along its sides which would have provided suitable places for camp or village sites. It contains no substantial barriers to the north-south movement of people and animals. Fourteenmile Creek has numerous localities which would have been suitable for placement of camps. Water is relatively available for most, if not all, of the year. Although there is no record of aboriginal use of the drainage, it is

reasonably likely that at least a few temporary camps are located along the canyon, probably at points where major tributaries enter. Since Sheep and Fourteenmile Creeks have not been thoroughly examined, the investigators recommended that on-the-ground inspection be undertaken if this route becomes the preferred access for bringing water to the Tract.

Hauling the by-products over existing highways by truck poses no threat to the cultural resources of Rio Blanco and Garfield Counties. But in the event that alignments need to be changed to accommodate heavy truck traffic, this conclusion would have to be investigated further with field studies of the realignment areas.